

PORTUGUESE CATHOLIC UNIVERSITY

SPECIAL STUDY OF INTERMEDIATE DYNAMICS AT THE BEGINNING OF THE 21ST CENTURY

Thesis submitted to the Portuguese Catholic University
for the degree of Doctor of *Science and Technology in the Arts Interactive Art*

by

André Rangel Macedo

SCHOOL OF ARTS
January 2014



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Under the supervision of Dr. Paulo Ferreira Lopes and co-supervision of Dr. Álvaro Manuel Mendes Barbosa

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SUMMARY

This research work, in the field of intermedia practice and thought, seeks to identify the main characteristics, dynamics and antecedents of this means of artistic expression, as well as the type of knowledge and skills inherent in the process of making and experiencing intermedia, interactive, multi-sensory works of art. Given the apparent lack of consensus among peers regarding the terminology and meaning of the term intermedia itself, the relevance of the intermedia concept, its emergence and the ways in which the knowledge generated by intermedia research can be disseminated in the fields of art and design are questioned.

The starting point is a process of reflective practical research, in which the design and construction of interactive intermedia systems is experimented with, integrating knowledge from a wide spectrum of scientific and artistic activities. The knowledge acquired in this process and the four resulting works support the review and analysis of literature, which allows us to identify characteristics of intermedia that are also verifiable in the works designed in this research project. The literature review is expanded to support a philosophical approach that, in addition to analysing and describing intermedia processes and knowledge, also contributes to a better understanding of the possibility of disseminating and validating these processes and knowledge in the academic context.

The relevance and adequacy of Coleridge's original concept of inter-medium is demonstrated, as well as the affinity of intermedia to experimental chemistry, given its transformative, laboratory-based, experimental nature and its ability to create new media from the fusion of existing media. This fact, as old and modern as humanity itself, allows us to affirm the permanent relevance of intermedia. In the sense of an approximation

the definition of intermedia, the main characteristics of its process and the resulting works are: fluidity, hybridity, indeterminacy, autopoiesis, synthesis, enaction, continuity, unclassifiability, serendipity, audience inclusion, and the evolutionary and subversive nature of the function of the media. This set of attributes is expanded to include the characteristics of presentation, indiscipline, unification, and equalisation of media.

It can be seen that the experience of making art and design as an activity of reflective practical research brings together theory and practice, countering the age-old division between *episthémé* and *techné*. The power that the intrinsic motivation of research has in the design of the research itself, as well as in its results, is emphasised. It should be noted that the knowledge involved in this type of research is essentially tacit, non-propositional, and therefore ineffable. However, it is transmissible and disseminable in a memetic way.

ABSTRACT

The aim of this research work, in the field of intermedia practice and thought, is to identify the main characteristics, dynamics and antecedents of this medium of artistic expression, as well as the type of knowledge and the types of skills inherent to the process of doing and experiencing inter-media, interactive, multi-sensorial works. In view of the apparent lack of peer consensus regarding terminology and the meaning of the word 'intermedia', we question the relevance of the concept of intermedia, its emergence and the ways in which knowledge generated by intermedia research can be disseminated, both in the fields of art and design.

We start from a process of practical reflexive investigation, in which we experiment with the design and construction of intermedia interactive systems, integrating knowledge from a wide spectrum of scientific and artistic activities. The knowledge acquired in this process and the resulting four works support the literature review and analysis, which allows us to identify intermedia characteristics that are also verifiable in the works designated in this research project. We amplify the literature review in order to support a philosophical approach that, in addition to the description and analysis of intermedia processes and knowledge, also contributes to a better understanding of the possibility of diffusion and validation of these processes and knowledge in the academic context.

We demonstrate the actuality and adequacy of Coleridge's original conception of the intermedium, as well as the affinity between intermedia and experimental chemistry, given its transformative, laboratory-based, experimental character and its ability to create new media through the fusion of already existing media. This fact, as old and as modern as humanity, allows us to affirm the constant relevance of intermedia. In order to approach a definition of intermedia, we highlight as main characteristics of its process and of

its consequent works: fluidity, hybridism, indetermination, self-poiesis, synthesis, enaction, continuity, unclassifiability, serendipity, inclusion of the audience, and the evolutionary and subversive character of the function of media. We expand the set of these attributes by proposing the inclusion of the following characters: presentative, indisciplinary, unifying and media equaliser.

We verify that the experience of making art and design as an activity of practical reflexive investigation combines theory and practice, counteracting the millennial schism between *epistêmê* and *technê*. We highlight the power that the intrinsic motivation of the investigative action has on the design of the investigation itself, as well as on its results. We emphasise that the type of knowledge implied in intermedia investigation is essentially tacit, non-propositional, and therefore ineffable. However, it is transmissible and transferable in a memetic way.

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LIST OF ABBREVIATIONS

3D [3 *Dimensions*] Three dimensions

BCI [*Brain Computer Interface*] Brain Computer Interface CIE [*Commission Internationale de l'Eclairage*] International International Lighting Commission

DMX [*Digital Multiplex*] Digital Multiplex

EEG Electroencephalogram

[*Light-emitting diode*] Diode

ORIP Works Resulting from Reflective Practical Research developed in this research project

RGB [*Red Green Blue*] Red Green Blue

VGA [*Video Graphics Array*] Video Graphics Array

INTRODUCTIO N

IMPORTANCE OF THE RESEARCH AND THE STUDY CONTEXT

The importance of this research lies in its ability to substantiate and affirm the influence and emergence of intermedia practice and thinking within and outside academia at the beginning of the 21st century. Based on reflective intermedia practice research, it appears that the term that best defines the dynamics of this type of practice and thinking is indiscipline.

The current controversy over the extemporaneity or [topicality] of intermedia thinking and practice, and over the very meaning of the term as a denominator of the results of various events, practices and thoughts in the field of art and design, was also understood as a problem of great importance deserving the attention of this research.

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l While Giannetti (2010) considers intermedia art to be 'somewhat outdated', 'linked to the theories and productions of the 1970s', Meier (2012) asserts that genuine thinking is intermedial. Not only is Meier's statement recent, but the term 'genuine' itself refers to something timeless, and therefore also current. Furthermore, the term 'intermedia' reappeared in the Portuguese academic landscape during the first decade of the 21st century, associated with the names of academic programmes and a research centre.

The academic context is part of a global system in which measurability, fragmentation, standardisation and classification justify the maintenance of a disciplinary system whose hierarchy results from an ancient divide between idealism and realism, and between theory and practice. In this system, reflective practical intermediary research aims to move forward, transcending any boundaries or disciplines and disregarding any hierarchy. Therefore, there is an urgent need for research that systematises the characteristics and (dis)framing of the type of knowledge generated in intermedia reflective practical research, formulating a hypothesis of how this knowledge and the results of such research can be disseminated, ensuring the requirements of academic research.

RESEARCH OBJECTIVES AND APPROACH

The practical reflective research work presented in this thesis aims to demonstrate the intermedia concept as an undisciplined creative process through the systematisation and development of models for the fusion of various means of expression. This undisciplined dynamic involves the convergence and fusion of a spectrum of media, from the arts to design, science and technology, resulting in new hybrid means of multisensory stimulation and provocation. The aim is to investigate the development, potential and framework of these means of expression by designing conditions that allow the presentation of intermedia works. It is therefore hoped that this research will support the hybrid and fluid nature of intermedia as a process and practice that underpins the approximation of artistic experimentation to scientific experimentation.

In this research, the aim of cultivating reflective practice, thinking and emerging study in the area of designing interactive multisensory intermedia systems is to contribute to fertilising this field for future research, as well as to assume and legitimise practice as a form of thinking.

In addition to attempting to master and disseminate the fusion of different digital and analogue algorithmic manipulation techniques, the aim is also to develop artistic intermedia systems capable of provoking movements of various qualities, which amplify human gestures in an interface that facilitates the stimulation and participation of users in the creative process. The aim is therefore to affirm the meta-concept, offering control and the advantages of final aesthetic decisions to the participants in the works, which exist as a space-time for integration, socialisation and communication, where audiovisual events are controlled through the body movement and gestures of the participants.

The intention is to demonstrate the indeterminism of the process of intermedia synthesis, associating it with some areas of science such as experimental chemistry, helping present and future artists and designers to understand without prejudice that the processes of creation and materialisation of works of art and design are often not governed by predetermined rules or theories.

In addition to the works resulting from reflective intermedia practice, the aim is also to produce a written result, in Portuguese, theorising on the dynamics of the changes and transformations that alter the form of existing media in an intermedia process. This literary piece is expected to serve as a future reference work in the field of intermedia studies, clarifying its emerging indiscipline, which is not sufficiently defined and validated in Portuguese academic and artistic circles. The aim of producing a practical-theoretical work, which will serve as a seed and contribution to literacy in the field of intermedia, will allow future generations to gain a cumulative understanding of the issues surrounding this interdisciplinary field, its historical context and its processes, enabling the development of new academic curricula.

METHODOLOGY

At the methodological level, three dimensions can be considered in this doctoral thesis: a general one, which determined the approaches to be developed, and two specific ones associated with the chosen approaches. As a general methodology, it was established that this doctoral thesis should be approached simultaneously through a process of reflective practical research in intermedia, resulting in intermedia works, and through a process of writing, resulting in the present literary piece.

The methodology affects the approach to reflective practical research and is determined by the research process itself. It is therefore more of an iterative methodological process, in which the research methodology itself is continuously analysed, reconsidered and redesigned to respond to the needs of each new stage in the research process. In other words, the research process integrates, shapes and determines the methodology, rather than the methodology determining the research process.

The methodology in the context of the written production of this literary piece, on the other hand, has a substantially different character. Although it also underwent a transformation, it determined the writing process. It was decided that the written thesis would be divided into two main chapters: the first, focused on theorising about the antecedents and concepts that support an approximation of a definition of intermedia, and a second chapter, in which a written rationale is developed that explains the process of conception and elaboration of intermedia works, resulting from the process of reflective practical research.

Regarding the writing methodology of the first chapter of this dissertation, the initial phase aimed to compile as many bibliographic references as possible on the subject, or literary works where the term intermedia was used in the context of art and de-

sign. After selecting more than 100 bibliographical references, including books, articles, theses, journals, and catalogues, among others, we considered the possibility of writing the first chapter of this thesis as a chronological approach to the evolution of the term's meaning.

In this approach, it was found that in the same year that Higgins proposed the term intermedia, other authors immediately incorporated it into their writings. In addition, from the analysis of the bibliography, in chronological order, some concepts associated with intermedia began to stand out due to the frequency with which they were referred to. This fact, combined with the data provided by the knowledge generated in the process of reflective practical research carried out in the experimental field, allowed these concepts to be upheld as unavoidable characteristics of the phenomenon of intermedia. Thus, the methodology for writing this chapter of the thesis was restructured, and it no longer had a chronological structure. The redesigned method determined that the writing should be guided by discussion poles, focused on the concepts and antecedents that, from the literature review, were considered most evident for the characterisation of intermedia dynamics, which could be verified in the reflective practical research process, as well as in the works resulting from this process.

STRUCTURE OF THE THESIS

The first chapter of this thesis begins with the section *Why intermedia?* which identifies as the starting point for this research the need to contextualise the artistic work of researcher André Rangel, as well as the main reasons that led to the development of this research. This section summarises how the concept, theme, practice and research of intermedia are insufficiently integrated into the academic curriculum in Portugal at the beginning of the 21st century. The undisciplined nature of intermedia is acknowledged as a factor of incompatibility with an academic disciplinary system with a strong tendency towards

measurability and monodisciplinarity. Also in this section, and based on statistical data resulting from a set of 100 interviews conducted as part of this research, the generalised lack of consensus and knowledge regarding the term intermedia is justified.

In *the* section *Higgins, Coleridge and Chemistry*, we first address the original conception of the term *intermedium*, proposed by Coleridge, its adaptation by Higgins, and suggest that this author maintains the prefix 'inter' in the term 'between' as a dimensional attribute. Next, Coleridge's original conception is reflected upon, and it is noted that the term he used belongs to the field of experimental chemistry and is, specifically, a synonym for chemical agent or catalyst. Thus, in this section, the importance of the notion of agency and transformation in the context of the present research is upheld. The affinity between intermedia, experimental chemistry and science is affirmed, emphasising its transformative, laboratory-based nature, its capacity for synthesis and for generating new means. At the end of this section, this affinity is reinforced by discussing serendipity, indeterminacy, and autopoiesis as characteristics inherent to both intermedia and some scientific practices.

Background and (in)classification is the section that identifies artistic advances prior to Higgins' proposal, which are considered to be related to the properties of the dynamics of intermedia action. It is also where the space-time of intermedia action is characterised and the difficulty of its categorisation and classification is reaffirmed. This section begins by clarifying the distinction between the concepts of intermedia and multimedia, supported, among other arguments, by the relational and plural characteristics associated with each of these two concepts.

This section discusses some of the advances made by artistic movements that were inherited by intermedia, giving as

examples: the shamelessness in relation to the use of any medium or the reactions of the public in Futurism; the heterogeneous strategies, the profound rejection of the traditional skills of artists and spontaneity in Dadaism; the inclusion of any combination of media in Fluxus; the liberation of media from their original functions in Ready-Made; the inclusion of the audience and indeterminacy in Happenings and in some works by John Cage, among others. This section also reflects on the appropriateness of the concepts of liminality, hybridity, holism, fluidity, continuity, or fusion as attributes of intermedia that justify its unclassifiability.

The chapter *on Experience* reflects on the relationship between the experience of the author of intermedia works, resulting from the process of reflective practical investigation, and the experience of the audience of these works. It also discusses the importance of gesture and movement by the audience when integrated into intermedia works. This section concludes by justifying how the intermedia works referred to are presentational and considered as spaces of enaction.

Given that this PhD developed a continuous research process based on and guided by reflective practice, the chapter *on Practice* supports the impact that reflective practice has on the researcher's knowledge and, consequently, on the knowledge that can be disseminated by this PhD work. A verbal theoretical justification is developed on formalised knowledge that is essentially non-verbal. The section begins with an analysis of the recognition that artistic practice has, as a credible research protocol, in the academic context. This analysis focuses on both legal aspects and the procedures within academia itself. Next, well-founded considerations are made about the reasons that have led to the still existing dispute and hierarchisation of knowledge, as well as the privilege of the written word as a vehicle for the transmission of knowledge. This section also discusses technology and technique as means of

indispensable to the intermediate process, as well as their importance from an epistemic point of view, in the perception and construction of knowledge. The conception of theory articulated and expressed exclusively through verbal language is questioned, as well as the adequacy of writing for recording and transmitting a large part of knowledge. Tacit knowledge is discussed as a privileged form of knowledge in the process of intermediate research. Action research, research through practice in a constructive process, and the possibility of transmitting tacit knowledge in a non-written form are debated. The possibility that works resulting from a process of reflective practice generate and contain knowledge about the very process of how they are made is argued. The semantic potential of the materials from which the works are made is also discussed, as well as the dialectic inherent in the artist's dialogue with the materials they use or reject in the making of the works. The hypothesis of the integration and validation of playful activity in artistic research in general, and in intermedia research in particular, is also elaborated. At the end of this section, the validation of an alternative to literature is suggested to ensure the reproducibility of the knowledge developed and resulting from a process of reflective practical research in the academic context.

In the chapter *Research Results: Intermedia Works*, a written rationale is developed that explains the process of conception and elaboration of the works resulting from the process of reflective practical research that were considered most relevant as a contribution to the evolution of knowledge in the field of art and intermedia design. In the first section of this chapter, Algorithm, Iteration, Stochastics and Computer, the use of computer programming as a means of fusion is introduced and discussed, as used in three of the works resulting from the research. The issue of fluidity resulting from the fusion of media when represented and modelled in the digital domain is addressed.

The section ColMus and SoLu, Proposal for correspondence, begins with a description of the problem that gave rise to the design of these works: the design of a proposal for correspondence between sound and light. This proposal is stated and the physical and mathematical foundations that support it are explained. It discusses the procedures and options taken to circumvent physical impossibilities and construct an approximate model that would allow the correspondence proposal to be demonstrated. It explains the process of designing and developing the hyperinstruments that make up the ColMus and SoLu works, justifying the aesthetic and technical choices made in their composition.

The GreenRay and SynDyn section brings together the literature that underpins and explains the process of designing and developing two works that can be considered as concepts of urban aesthetics. It deepens a reflection on the notion of space in the works referred to as a structural fusion of the human organism with its environment. In the last section, Dissemination of the works, in order to confirm the works resulting from this research as a contribution to knowledge, examples are presented of how these works have already been disseminated.

In the appendices to this thesis, the first section contains a list of the hundred individuals interviewed with the aim of updating the definition of the term 'intermedia' and assessing the interviewees' real understanding of the problems involved in this definition. Transcripts of excerpts from these interviews that proved to be most relevant in response to three questions used in the interviews are compiled: What does media mean? What does intermedia mean? And what is the relationship between theory and practice?

Also included in the appendices to this thesis are brief presentations of other results from the research process developed in this doctoral thesis

, including works authored by the researcher, collaborative works, and a collaboration on another researcher's doctoral project.

INTERMEDIA

WHY INTERMEDIA?

The starting point for this research work dates back to the beginning of the first decade of the 21st century, with the need to categorise and frame the artistic work developed by the researcher, André Rangel, who since 2003 has integrated it into the field of intermedia art and design.

Another reason that triggered the development of this study stems from the void that existed in the national academic and artistic milieu in the early years of the century regarding the concept, theme, practice and research of intermedia. These facts led to the drafting of the first proposal for this doctoral project in 2006, which was submitted to and accepted by the Scientific Council of the Portuguese Catholic University.

Until 2012, the term intermedia appeared associated with only four programmes in the first and second cycles of higher education in Portugal. At the University of Évora, the 'Master's Degree in Visual Arts' was introduced

in the 2004/2005 academic year, with the following areas of specialisation: 'Three-dimensional Intermedia', 'Two-dimensional Intermedia' and 'Digital Intermedia'. In Porto, the Master's Degree in Graphic Design and Production/Intermedia was taught in partnership with the training entity Alquimia da Cor in the 2005/2006 academic year. A year later, in 2007/2008, the 'Bachelor's Degree in Fine Arts and Intermedia' was introduced at the Porto School of Art, and the Bachelor's Degree in 'Fine Arts — Painting and Intermedia' at the Tomar Polytechnic Institute. In 2011, NAi — Núcleo de Arte e Intermedia (Art and Intermedia Centre) was created at i2ADS — Instituto de Investigação em Arte, Design e Sociedade (Institute for Research in Art, Design and Society).

It is clear that in the first decade of the 21st century, there were no academic courses in the field of intermedia. An analysis of the syllabuses of the courses mentioned shows that, with the exception of the Master's Degree in Graphic Design and Production/Intermedia, there are no courses specifically dedicated to intermedia. In the names of the courses mentioned, the word intermedia appears as an appendix or as an adjective. Without intending to make a thorough critical analysis of any of the names of the courses mentioned or their curricula, it can be seen that intermedia appears in a timid and even incoherent way, not being fully accepted as an autonomous practice and way of thinking. In the courses mentioned, there is a clear tendency to reduce intermedia to the visual, graphic and/or plastic arts.

It is known that intermedia is an enabler of integration and can involve any medium or form of expression, so calling it three-dimensional, two-dimensional or digital intermedia is a perverse way of delimiting fields of action, which in itself contradicts the essence of intermedia itself. This confirms that until the mid-2000s/2010s, there was no training available in intermedia, and it was only in the second half of the decade that training was introduced, but in a timid and constrained manner.

In fact, one of the reasons why intermedia has not yet been accepted in the national academic environment as an autonomous curriculum may be related to its hybrid nature, a concept that will be developed and explained in this thesis. Intermedia can hardly be adapted to an educational, cultural and political system based precisely on the division and measurability of knowledge into areas and disciplines, since intermedia cannot be approached from a monodisciplinary point of view [2].

In this research, intermediation is considered as 'indiscipline', since in the term indiscipline, the prefix 'in' can be interpreted both as a value of negation and as a place and movement within discipline. It is possible that reflective intermedia practice has not yet been adopted as an academic curriculum or form of research because it is difficult to sustain and defend the idea of indiscipline in academia. As Braun and Aziosmanoff (2009) state, intermedia is an emerging discipline that tends to break with most categories, especially those associated with specific disciplines.

In addition to the lack of specific training in the field of intermedia, when the decision was made to proceed with this doctoral project, it was found that among peers (teachers, researchers, artists, and designers), the terminology and meaning of intermedia was not only not consensual, but often unknown. In a decade in which the word media appears associated with many terms used to categorise works

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2 Oosterling (2003) considers that even in art theory, there was a gap of about 25 years after the end of the 1960s in the debate on intermedia, and that the texts produced in the 1990s explored disciplinary crossovers, but none of them truly addressed the ontological dimension of the term 'inter'.
In art theory, it took another 25 years before intermediality became a topic of debate. In the first half of the nineties, some relevant books on inter-mediality were published in Germany. Since then, mono-disciplinary approaches have no longer been taken as adequate models for analysing and evaluating contemporary art practices. Most of these texts have examined and explored the crossovers between literature, theatre, cinema and visual arts, but none of them have taken the ontological dimension of the "inter" seriously.
(Oosterling, 2003, p.35)

3 In the same text, the authors add: 'An introduction to intermedia artistic practices will provide an initial context for understanding the dismantling and reassembly of core disciplines in current information design.'
Translation by the author from the original:
'An introduction to intermedial art practices will provide a first context for understanding the dismantling and re-mantling of disciplines at the heart of information design today.'
(Braun and Aziosmanoff, 2009, p. 254/2)

In the fields of design and art, many of which have a strong digital component, the distinction between the various [terms] was still unclear among peers.

This fact is documented in a series of 100 [interviews5] conducted during this research in various countries with individuals directly involved in the production of works in the fields of music, art and design. It should be noted that 23 of these 100 interviews were conducted with participants selected to present their work at the ‘Intermedia Festival’ in Indianapolis. Of the 100 responses to the question 'what does intermedia mean', 54 people said they had never heard of the term, had never thought about it, were not sure what it meant, or did not know its meaning. Of the 46 people who ventured a definition of the term intermedia, only 4, or just 4% of the total, mentioned the name of Dick Higgins as a historical reference. The important thing in these interviews is not to highlight the lack of knowledge on the subject, but rather to reinforce the importance of this text as a means of clarification. However, the answers given by the interviewees to the question 'what is intermedia' also contain statements and opinions that can help to construct a definition of intermedia.

Thus, in the following sections of this paper, we will discuss the origin of the term intermedia, as well as the historical context in which this phenomenon developed. We will also discuss concepts considered to be its antecedents, which will allow for a theoretical approach to what can be characterised as intermedia.

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4 Hypermedia, Newmedia, Mixedmedia, Moistmedia, and Multimedia are some of the terms used at the beginning of the 21st century to identify works that use a variety of media for their realisation.

5 In the appendices to this thesis, in the 'Interviews' section, all the personalities interviewed are identified, and transcripts of the most relevant excerpts from the interviews are presented. All interviews are available for consultation at the following URL: http://hyperinstrument.com/interviews

HIGGINS, COLERIDGE AND CHEMISTRY

The historical origin of the term intermedia was initially linked to experimental chemistry in the early 19th century. In the 1970s, the term reappeared in association with a cross-disciplinary artistic approach. In the following sections, we will discuss the continuing relevance of Coleridge's original conception of the term intermedia, observing the dynamics of reflective intermedia practice as a transformative catalyst capable of generating new media in an indeterminate process that fosters [serendipity].

HIGGINS AND COLERIDGE

In fact, the term Intermedia [7] coined by Dick Higgins predates the term Multimedia (Zuras, 2010)[8]. According to Kostelanetz (1999), Higgins has always made it very clear that there should be no limits to creative activities. Higgins (1966b) used the term intermedia to categorise works of art that he felt were between [media]. Schneider (2000) considers that Higgins, by describing with the term intermedia artistic works that operate at the interfaces of established media and in the interstices between art and life, anticipated the postmodern preference for hybridism, to the detriment of formal unity, as well as the challenge of art as a pure ontological category.

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6 According to Melo and Carvalhais (2013), serendipity can be described as the accidental discovery of significant information, made possible by the observer's sagacity.

7 It should be clarified that the term Intermedia in this study does not refer to the meaning given by authors such as Margery Stomne Selden (Selden, 1962), who uses it to identify the insertions between acts in plays, or to the meaning given by John T. Caldwell (Caldwell, 1993), who uses the term critically, instead of 'intertext', to classify how television, as a medium more preoccupied with visual forms than literary forms, becomes a pervasive machine that blurs the boundaries between different types of images.

8 Zuras, Matthew. (2010, June 3). Tech Art History, Part 2. Switched. Retrieved from http://www.switched.com/2010/06/03/tech-art-history-part-2/

9 *'Much of the best work being produced today seems to fall between* media' Higgins, Dick 1966 in: 'Intermedia', Something Else Newsletter Number 1 Volume 1

It is curious to note the coincidence of the appearance of the term intermedia, written for the first time in the first issue of *'the something else* newsletter', where Higgins distinguishes Marcel Duchamp's work from Picasso's, precisely because Duchamp's work is truly 'between media, between sculpture and something else'[10]. One could speculate on the very name of *the newsletter*, *'the something else'*[11], but it seems more interesting to note the recurrence of the word 'between' in Higgins' text. In fact, the prefix 'inter' is sustained throughout Higgins' text by the word 'between'[12]. In this research, the term 'between' was considered a keyword: working 'between' different disciplines, between different areas of knowledge and between different experiences.

In the reflective intermedia practical research developed in this doctoral thesis, the word 'between' can help to understand and contextualise the type of works resulting from this research. These works fall within a hybrid area, somewhere between Visual Art, Sound Art, Architecture, Design, Performance, Science, among others. According to the Portuguese language dictionary, the word 'between' derives from and is synonymous with the Latin word inter. In other words, in a first etymological interpretation of the term, we would understand intermedia as 'in between'.

It is agreed in the literature reviewed in this research that Higgins was the first human being to write the word intermedia. However, about

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10 *'Part of the reason that Duchamp's objects are fascinating while Picasso's voice is fading is that the Duchamp pieces are truly between media, between sculpture and something else, while a Picasso is readily classifiable as a painted ornament.*' (Higgins, 1966b)

11 In an interview with Zurbrugg, Higgins recalls what he wrote in his *A Something Else Manifesto*: *'Whatever the other people are doing, I'll do something else.*'

12 *'The concept of the separation* ***between*** *media arose in the Renaissance. […] Duchamp pieces are truly* ***between*** *media,* ***between*** *sculpture and something else […] by invading the land* ***between*** *collage and photography, the German John Heartfield produced what are probably the greatest graphics of our century […] The ready-made or found object, in a sense an intermedium since it was not intended to conform to the pure medium, usually suggests this, and therefore suggests a location in the field* ***between*** *the general area of art media and those of life media. […] I cannot, for example, name work which has consciously been placed in the intermedium* ***between*** *painting and shoes. The closest thing would seem to be the sculpture of Claes Oldenburg, which falls* ***between*** *sculpture and hamburgers (...)*' (Higgins, 1966b)

A century earlier, Samuel Taylor Coleridge had already introduced the term *intermedium* in his 1817 work ‘Literary Biography’.

> Consequently, since metre has often been related to poetry and by a peculiar aptitude, whatever combines with metre must, even if it is not in itself essentially poetic, nevertheless have some property in common with poetry, as an intermedium of affinity, a kind of (if I may venture to borrow a well-known expression from technical chemistry) of a catalyst between poetry and the superimposed metre.[13]

In an interview with Nicholas Zurbrugg, Higgins confirms that he revived Coleridge's term:

> I revived this term from Coleridge. He used it in a lecture he wrote in 1814 and published in 1816, and as far as I know he used it only once. But it was such an impressive notion that when I came across it, it was easy to appropriate. I must have come across it when I was a language student at Yale or Columbia in the late 1950s, and it was more or less forgotten until I needed it in 1963.[14]

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13 Translation by the author from the original by Samuel Taylor Coleridge: *'Metre, therefore, having been connected with poetry most often and by a peculiar fitness, whatever else is combined with metre must, though it be not itself essentially poetic, have nevertheless some property in common with poetry, as an intermedium of affinity, a sort, (if I may dare borrow a well-known phrase from technical chemistry), of mordaunt between it and the super-added metre.*' Note that the term *mordaunt* is, as far as we know, untranslatable; we propose an inferential approximation of its meaning.

14 Translation by the author from the original: *‘I revived this term from Coleridge. He used it in a lecture that he wrote in 1814 and which he published in 1816, and used it only once as far as I know. But it was such a striking notion that when I came across it, it was easy to pick up. I must have come across it when I was a language student at Yale or Columbia in the late fifties, and more or less forgot about it until I needed it in 1963*.’ (Zurbrugg & Higgins, 1963, p. 24)

The one-year difference between the publication date of Literary Biography (1817) and the date referred to by Higgins in the interview (1816) is explored and commented on in Julian Sumich's thesis, when he states that this one-year difference may be related to the fact that Coleridge began writing the work in 1815 and only published it in 1817 (Sumich, 2006).

The notion of intermedia that is of interest to explore in this investigation is precisely the notion of the 'transforming chemical agent'. Coleridge is clear: "... *an **intermedium** of affinity, a sort [...] of mordaunt...".* The *intermedium* as a kind of *mordaunt*. Although the word *mordaunt* does not appear in modern English dictionaries, Dr Alice Eldridge has informed us that this word is a technical term from ancient chemistry meaning 'a common base'[15]. Catalyst is thus the inferential approximation to the meaning of *mordaunt* proposed in this study. Thus, according to Coleridge, we would have the intermedium as a kind of catalyst, establishing, from the outset, the affinity of the intermedium with the chemical agent.

The next section aims to affirm the relevance of this affinity through a review of the literature, particularly from the first decade of the 21st century, which confirms this phenomenon.

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15 *'I think it's an old-fashioned technical chemistry term meaning a common base - like a common ancestor.'* (Eldridge, 2013)

16 It is fascinating to note the relevance of Coleridge's idea of the intermediary as a catalyst, as during the writing of this text, information became available about an exhibition organised by *Ars* Electrónica entitled *'Artist As* Catalysts', which will take place in September 2013. The presentation text for this exhibition states that 'artists and their works function as catalysts' and that 'members of the audience are cordially invited to get involved' in the exhibition, whose theme is 'Express Yourself', which 'should be understood literally as
a call to action'. Source: http://export.aec.at/bilbao2013/
Furthermore, this exhibition reinforces the relevance and urgency of the works developed in this PhD precisely because they are a 11 an invitation to the audience to take action.
Exactly four decades ago, Cornock and Edmonds also wrote about the artist: '*[...]it may no longer be necessary to assume that he is a specialist in art - rather he is a catalyst of creative activity.*' (Cornock and Edmonds, 1973)

AFFINITY WITH CHEMISTRY

The affinity between intermedia and chemistry is corroborated by Sumich (2006), almost 200 years after Coleridge. In the first chapter of his thesis, Sumich equates intermedia with experimental chemistry. Chemistry, as defined by Collins English Dictionary, is the branch of science concerned with the composition, properties and reactions of substances; with the composition, properties and reactions of a particular substance; with the nature and effects of any complex phenomenon, such as the chemistry of love; or with the instinctive reaction between two people.

Eisenkraft (et al., 2006) state that all artists are chemists because they 'study and understand the properties of specific materials — media — and find ways to exploit those properties' to express themselves. According to these authors, artists become chemists because of their need to understand the materials they use, as well as their interactions. For Eisenkraft (et al.), chemistry boils down to change. Glusberg (1980) believes that as an artistic manifestation, intermedia is a laboratory for art, 'an unusual laboratory, where technical and communication media are the guinea pigs'. In this sense, it is possible to affirm the affinity between intermedia and chemistry, as both essentially deal with transformation and also operate at a laboratory level.

The affinity between intermedia and chemistry is also supported by the arguments put forward by Spector and Spalding (2003) in their discussion of art and chemistry, in which they identify, for example, the use of metaphor, transformation,

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17 Sumich (2006) deduces the hypothesis that Intermedia Art is fundamentally philosophical, scientific and artistic in its origin and character.

18 Translation by the author from the original: *'the branch of physical science concerned with the composition, properties, and reactions of substances See also inorganic chemistry, organic chemistry, physical chemistry*
the composition, properties, and reactions of a particular substance
the nature and effects of any complex phenomenon ⇒ the chemistry of humour (informal)
a reaction, taken to be instinctual, between two persons'
(http://www.collinsdictionary.com/)

19 Translation by the author from the original: *'This is why we believe that intermediaries in their artistic manifestation are a laboratory for art. An unusual laboratory, though, where technical and communications media are the guinea* pigs' (Glusberg, 1980).

synthesis, product manufacturing, symbolic language, experimental vocabulary, devices and equipment.[20] These resources are indisputably recurrent in both the field of intermedia and chemistry. Kultermann (1980) had already identified one of these resources as a characteristic of intermedia when he stated: 'One of the characteristics of intermedia is its synthesising nature'.21 As will be explained in the section 'Holistic and Hybrid', intermedia generates something new and liminal from the transformation of existing media. This capacity is one of the greatest affinities between intermedia and chemistry.

Spector (2003) stated:

> Much of chemistry's identity as a discipline is related to the generation of materials that did not previously exist and have no natural equivalent, rather than to understanding what exists in the natural world [...] For me, all these issues of natural/synthetic/imitative/novelty are also related to questions of originality, which is another point of connection between chemistry and art [...]. (p. 240)

If we replace the word chemistry with intermedia and the word materials with means in the first part of the first sentence of the previous quote, we get: 'Much of intermedia's identity as an (in)discipline is related to the generation of means that did not exist before'. What makes ab-

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20 '[...] the metaphorical aspects of chemistry - transformation, synthesis and production of products - and perhaps the symbolic lineage, the experimental vocabulary and the apparatus of chemistry'.
Translation by the author from the original:
'*[...]the metaphorical aspects of chemistry - the transformation, synthesis, and production of products - and perhaps the symbolic language and the experimental vocabulary and apparatus of chemistry*.' (Spector & Spalding, 2003)

21 Translation by the author from the original: *'One of the characteristics of intermedia is its synthesising character*.' (Kultermann, 1980)

22 Translation by the author from the original: *'Much of the identity of chemistry as a discipline is related to the generation of materials that have not existed before and have no natural equivalent, rather than to understanding what exists in the natural world – what chemists like to call "novel" molecules, compounds, or materials. To me, all these issues of natural/synthetic/imitation/novel also relate to issues of originality, which is another point of connection between chemistry and art [...]*' (Spector and Spalding, 2003, p. 240)

solute meaning and reinforces one of the ideas that this study seeks to affirm: intermediation as an essentially presentative phenomenon23 rather than representative or mimetic, as in many traditional art forms.

Another of the great affinities between art and chemistry is undoubtedly the transformation of materials and laboratory practice. Since ancient times, understanding the properties and characteristics of materials has been a fundamental component of artistic production. Levere (2001) even titles his 'History of Chemistry' as 'Transforming Matter'24, a work in which he studies the transformations of different types of matter, from the principles of alchemy to the present day, and summarises the technical skills of chemistry applied to the manipulation, separation, combination and modification of different substances. These skills are very similar to those practised by intermedia artists and designers. Gardinali (2012), in one of his study programmes exploring the relationship between chemistry and art, states that since the discovery of fire, artists have made creative and exhaustive use of the materials at their disposal. It is widely agreed that the activity of artists and chemists is transformative. Moody (2000) even refers to a reciprocal relationship between materials and artists, when he considers that 'the materials available to artists influence the type of work that these artists can produce, and [....] the desire to produce different artistic works can influence the development of materials'25 . Furthermore, he states that both 'artists and chemists greatly value personal interaction and experimentation with materials', i.e. the laboratory component that allows for the growth of individual understanding of the media.

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23 We suggest consulting the article: 'From the Art of Representation to the Art of Presentation – a change accelerated by communication technologies and real-time information processing.' (Macedo, 2010)

24 Translation by the author from the original title: *'Transforming matter: a history of chemistry from alchemy to the buckyball.*'

25 Translation by the author from the original: '*[…] the materials available to artists affect what types of artistic work they are able to produce, and […] the drive to produce different artistic works can influence the development of materials for those artists*.' (Moody, 2000)

Another of the two great affinities between intermedia and chemistry is the fact that both are essentially procedural and transformative, which enables the unexpected, serendipity and the indeterminate nature of chemistry and intermedia. Serendipity may [be] one of the greatest motivations for artists and chemists in their work processes. Spector (2003) states that it is chemistry itself that seduces the chemist's imagination, which sometimes creates an inherent tension between the enchantment with the work they are developing and its final result (p. 253). This is absolutely true for intermedia as well as for artistic creation, and Spector reiterates this idea when he states that 'in this way, chemistry seems parallel to the artistic process, where there is very often a separation between the artist's conception and the art they [produce'] (p. 237).

Still in the sense of affirming the affinity between intermedia and chemistry, reference should be made to the issue of 'indiscipline' and the breaking of disciplinary boundaries as a quality of intermedia. As will be argued later in this thesis, ‘indiscipline’ is also a quality of chemistry, since, according to Spalding (2003), ‘it is surprising that chemistry can operate beyond the limits of more traditional notions of [scientific reason’][28] (p. 236). Roald Hoffmann is a staunch advocate of the deep connections, affinities and relationships between art and chemistry. One of these is precisely the creation of means (any type of means, from material to conceptual) that did not previously exist. Hoffmann (1993), who places chemistry in the domain of science, states:

> Art and science share the desire to know what is not yet known. They share so many things: the nature of

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26 In the case of the works resulting from this PhD, serendipity was one of the greatest motivations for its development.

27 Translation by the author from the original: *‘In that way chemistry seems parallel to the artistic process, where there is often a disjunction between an artist's conception and the art he produces*.’ (Spector and Spalding, 2003, p. 237)

28 Translation by the author from the original: *‘It is surprising that chemistry can take us outside the bounds of more traditional notions of scientific reason*.’ (Spector and Spalding, 2003, p. 236)

> research, the intellectual process, the formulation of ideas, concentration on the observable, in-depth examination of the nature of perception and how perceptions change with the observer. Chemistry and art synthesise the fusion of ancient knowledge with new observations to provide new concepts of nature or human relationship with nature[29] (p. 9).

Montes (2013) emphasises that Hoffmann, in addition to lamenting and considering the separation of the arts and sciences to be a loss, stresses the importance of skill, both in chemistry and in art, arguing that in both areas there is a mixture of manual and mental work. Hoffmann (1993) states that 'the aesthetic principles of science are not so different from those of art. Beauty, elegance, and deep understanding are as sought after by chemists as they are by artists' (pp. 8 and 9). In conclusion, and as will be argued in the section 'Holistic and Hybrid', intermedia is precisely a transformative, synthetic, laboratory-based, experimental process capable of generating new media. In the next section, based on the relationship between serendipity and indeterminacy as an essential condition for intermedia, its open autopoietic character will be defended.

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29 Translation by the author from the original: *'Art and science share a desire for knowing that which is not yet known. They share so many things: the nature of inquiry, the intellectual process, the formulation of ideas, a concentration on the observable, a deep examination of the nature of perception and the ways perceptions change with the observer. Chemistry and art synthesise by melding old knowledge with new observations to provide us with novel concepts of nature or of the human relationship to nature*.' (Hoffmann, 1993, p. 9)

30 In the original 'craft', in the context of this research, this word is associated with the know-how that will be discussed in the chapter 'Practice'.

31 *'Most crafts involve some kind of chemistry, usually learned through apprenticeship and practice. […] In chemistry as in craft, hands and minds work together creatively to produce useful, and often beautiful, things.'* (Hoffmann, 2012)

32 Translation by the author from the original: *'The aesthetic principles of science are not that different from those of art. Beauty, elegance, deep understanding are sought by chemists just as much as they are by artists*.' (Hoffmann, 1993, pp. 8 & 9)

SERENDIPITY, INDETERMINACY AND AUTOPOIETIC INTERMEDIA

Hoffmann seems to have experienced indeterminacy and serendipity in co-organising the book/exhibition *Chemistry* Imagined, when he states that his 'initial conception […] was typically scientific, and therefore linear. [… But the] nature of the creative process has ways of subverting such linear plans. And the work of art [...] carves out its own space'[33] (Hoffmann, 1993, p. 9-10). In this reflection, Hoffmann confirms the idea that the artist's production is often induced and guided by the very process of producing their work, which includes all (in)determinants. Indeterminacy as a quality of intermedia is discussed and sustained in the section 'Audience, Indeterminacy', but it is worth noting that for some thinkers and scientists, indeterminacy is also a quality of science. Elstob (1986) notes that the philosopher Karl Popper demonstrates precisely that 'even within its conceptual framework, scientific determinism shows an inherent indeterminism'[34] (p. 80). Physicist-chemist Ilya Prigogine[35], who challenged scientific determinism, also seems to affirm indeterminism and chance as an integral part of systems[36] theory according to Elstob (1986):

> [in Prigogine's treatise] indeterminism arises from points of thermodynamic bifurcation where random events determine the future course of a system. One consequence of this view is that the structures that now exist in the world may have resulted from events

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33 Translation by the author from the original: *'My initial conception […] was typically scientistic, therefore linear. […] The nature of the creative process has ways of subverting such linear plans. And the work of art -[…]- carves out its own space.*' (Hoffmann, 1993, pp. 9–10)

34 Translation by the author from the original: *'Popper is showing that even within its own conceptual framework the deterministic scientific view exhibits an inherent indeterminism.*' (Elstob, 1986, p. 80)

35 1917–2003

36 Thought and knowledge sustained and/or produced by systems have existed since ancient times if we consider that all phenomena can be seen as a network of relationships between elements or as systems. It was in the mid-20th century that systems theory was developed and applied to electricity, biology, society and even philosophy with a view to better understanding the complex behaviour of phenomena. This theory considers open and closed systems, the former being characterised precisely by their continuous interaction
with their environment.

> purely accidental, thus denying the universal operation of determinism. [37](p. 80).

Zatti (2003) uses the title 'Indeterminacy: A Necessary Condition for Free Will' in one of his writings, where he discusses the possibility that the nature of the universe is accidental. Possibly, indeterminacy as an inherent feature of life and nature[38] justifies its use by artists who seek precisely to bring their work closer to and integrate it into life and nature. In this sense, it can be concluded that in the specific case of the works developed in this PhD project, indeterminacy is associated with their artistic and creative processes, which are assumed to be open, transdisciplinary and interdisciplinary autopoietic systems.

In the context of this research, the term ‘open autopoietics’ was used as a meta-abstraction of the concept of ‘autopoiesis’ originally introduced by the philosopher-biologists Humberto Maturana and Francisco Varela, more precisely as an abstraction of Luhmann’s concept of ‘autopoiesis’, which in turn is already an abstraction of the original concept. For Maturana and Varela (1980), ‘the creation of any system depends on the presence of the components that constitute it, as well as the types of interactions between them; […]’ (p. 95). It should be noted that in 1980, Kultermann (1980) also characterised intermedia as an open system, giving as an example the relationship between artist and audience. According to Seidl (2004), in the original concept of autopoiesis (in the field of biology), ‘the elements of autopoietic systems are not produced by something outside the system

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37 Translation by the author from the original: *‘In this treatment, the indeterminism arises from thermodynamic bifurcation points where random events are what determine the future course of a system. A consequence of this view is that structures that now exist in the whorl may have resulted from purely chance events, thus denying the universal operation of determinism*.’ (Elstob, 1986, p. 80)For further clarification on ‘thermodynamic bifurcation’, we suggest reading the article *‘Order Versus Chaos or the Ghost of* Indeterminacy’, in which Giuculesco (1998) points out that the same
These types of processes occur in the natural world without external intervention and were termed autopoietic by Francisco Varela.

38 ‘Uncertainty is a basic fact of biology. […] All cultures have known and used this uncertainty for advice and knowledge' (Nelson, 1982, p. 13). Translation by the author from the original: *'Indeterminacy is a basic fact of biology. [...] Every culture has known and used this uncertainty for advice and knowledge*.' (Nelson, 1982, p. 13).

39 Translation by the author from the original: ‘*[T]he establishment of any system depends on the presence of the components that constitute it, and on the kinds of interactions in which they may enter; thus given the proper components and the proper concatenation of their interactions, the system is realised*.’ (Maturana et al., 1980, p.95)

ma', meaning 'all processes of autopoietic systems are produced by the system itself', whereby Seidl states that 'autopoietic systems are operationally closed' because there are no external operations entering the system and vice versa. In the Web Dictionary of Cybernetics and Systems, Heylighen's (2013) definition of autopoiesis reiterates the original biological concept when he states that 'an autopoietic system is operationally closed and has a determined structural state with no apparent inputs or outputs'. Niklas Luhmann applied the concept to sociology not directly, but as a radical abstraction of the original biological concept, transforming it into a general, transdisciplinary and open concept of autopoiesis. Luhmann (1986) states that 'the emerging view is that the phenomena of interest to evolution are special types of systems: open systems, that is, those that can exchange energy, matter and information with their environment' (p. 148). About a decade later, Guattari (1995), with or without knowledge of Luhmann's abstraction, also reformulates and opens up Matura's original concept of cellular biology when he writes:

> Autopoiesis deserves to be rethought in terms of collective, evolutionary entities that maintain various types of relations of otherness, rather than being relentlessly closed in on themselves. Institutions and technical machines appear to be allopoietic, but when considered in the context of machined assemblages

40 Translation by the author from the original: *'An autopoietic system is operationally closed and structurally state determined with no apparent inputs and outputs*.' In *'Web Dictionary of Cybernetics and Systems*'. http://pespmc1.vub.ac.be/ASC/AUTOPOIESIS.html

41 Translation by the author from the original: *'The emerging insight is that the phenomena of interest for evolution are special kinds of systems: open systems, that is, those that can exchange energy, matter and information with their environment. Evolution occurs when such systems are exposed to massive enduring energy flows*.' (Luhmann, 1986, p.148).

> constituted with human beings, become ipso facto autopoietic (p. 39-40)[42].

According to Doruff (2008), Guattari appeals to creativity as a means of expanding homeostatic, self-referential, closed systems to make them open, new and imaginative. The Priberam Dictionary of the Portuguese Language defines autopoiesis in the field of biology as 'the condition of a living being or system that continuously produces itself'. This description of autopoiesis makes no reference to it being a condition closed to exchanges between the system or being and its exterior. Hall (2010) considers that 'applied to aesthetics, autopoiesis replaces an objective external view of art with an internal relativistic understanding of creation. [And] This can be considered a self-functional aesthetic system that is open to negotiation.'[44] These arguments confirm that Maturana's original, closed concept has evolved into an open concept of autopoiesis, which supports what may be the theoretical contribution of this doctoral thesis: to affirm the dynamics of the processes of creation and production of intermedia works at the beginning of the 21st century as open autopoietic dynamics. Spielmann (2005) states that

> intermedia works are formed by the exchange and transformation of elements from different media. It is from this perspective and on these grounds that the expression 'open autopoiesis' is abstracted, open to exchanges with the outside world that contribute to shaping the very structure of intermedia creation and production systems, as well as the resulting work. In this sense, this thesis contributes to the construction and evolution of the very concept of autopoiesis in the context of intermedia research.

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42 Translation by the author from the original: *'Autopoiesis deserves to be rethought in terms of evolutionary, collective entities, which maintain diverse types of relations of alterity, rather than being implacably closed in on themselves. In such a case institutions and technical machines appear to be allopoietic, but when one considers them in the context of machinic Assemblages they constitute with human beings, they become ipso facto* auto-poietic.' (Guattari, 1995, p.39-40)

43 Hardt (2005) also considers that 'Intermedia as a creative environment – more specifically as a vehicle for artistic expression – promotes accessibility to ideas by making use of a banal familiarity with communication technologies' (p. 236). This consideration also supports what is stated in this thesis: intermedia as a process of hybridisation of living and non-living components.

44 Translation by the author from the original: *'Applied to aesthetics, autopoiesis replaces an external objective view of art with an internal relativistic understanding of creation. This can be described as a self-functioning system of aesthetics that is open to negotiation*.' (Hall, 2010)

To summarise the above, the system of intermedia creation and production, like any other system, depends on the interaction of its components. In this sense, and as will be discussed in the section ‘Audience, Indeterminacy and John Cage,’ when referring to the equity of the media, the viewer is precisely one of the components of the intermedia system, that is, a medium. Without wishing to absolve the author of responsibility, this thesis asserts that the hybrid author/artist/designer/producer does not play a central role, but is merely indispensable as a component of the intermedia system. It is only one of the media that make up an intermedia system. Intermedia thus results from the interaction of the media that compose it. It is therefore indisputably interactive and even enactive, if we consider the interaction and exchanges between the means that make up the intermedia system as a phenomenon of communication.

Clark (2011), who studies autopoiesis as the basis for an expansion of the interactive artistic system, recovers the classic model of artistic system proposed by Cornock and Edmonds (1973), consisting of the artist, the participants, the work, the environment in which these elements are placed, and the dynamic processes or interactions that result from this constitution. Taking ORIP as a reference, it can be concluded that the intermediate work emancipates itself from the system, asserting itself as the system itself — an open autopoietic
— of conception, production and materialisation and not as an element or component of the system, as argued by Clark, Cornock and Edmunds.

Still on the subject of applying autopoiesis to aesthetics, Hall (2010) considers interactive works of art to be evolutionary systems, where the artistic object and the viewer become co-organisers, creating an emerging aesthetic. Hall's idea is very close to the concept of enaction, if we consider the capacity for sharing proposed by Teixeira (1998) when he considers that 'the activity of communication does not consist in the transfer of information from the sender to the receiver, but in the mutual modulation of a common world through joint action' (p.

147). This joint action of human beings as means of intermediation gives it its evolutionary and enactive interface character.

Given the affinity of intermedia with experimental chemistry (due to its procedural and transformative nature) and with biology (due to its open autopoietic nature), it is also important to highlight intermedia as a hybrid of living and non-living beings, such as mechanical, electronic or computer systems. This hybrid character of intermedia can be supported by Barton (2008) when he states that 'intermedia attempts *to enact* the symbiosis of body and machine, locating them in the experiential context of contemporary experience.'

Although the 'Holistic and Hybrid' section of this thesis supports the hybrid nature of intermedia, it is nevertheless appropriate to refer to the 'autopoietic principle' of 'hybrid constitution' proposed by Francesco Monico (n.d.):

> Every living and non-living being must be respected in its "self-creation" and in the expression of the fundamental dialectic between its structure, mechanism and function. As an organised unit, as a network of processes of transformation and destruction of components which, through their transformations, continuously regenerate and materialise the network of relationships that produced them and constituted them as a concrete unit in the space in which they exist, specifying the typological domain of their materialisation as a network.[47]

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45 Enactive is a term derived from the English word enact and is related to action, doing or putting into practice. According to Pasquinelli and Stewart (2007), enactive knowledge is a form of knowledge characterised by not being propositional. Being primarily knowledge for action, action is necessary for its acquisition. It is knowledge stored in the form of motor action. An enactive interface uses enactive knowledge instead of symbolic and/or iconic language.

46 Translation by the author from the original: '*[…]intermedia often attempts to enact the symbiosis of body and machine, locating each within the lived context of contemporary experience*.' (Barton, 2008)

47 Translation by the author from the original: *'Every living and non-living being has to be respected in its "self-creation" and in its expression of a fundamental dialectic between structure, mechanism and function. As an organised unity, as a network of processes of transformation and destruction of components which, through their transformations, continuously regenerate and realise the network of relations that produced them, and constitute it as a concrete unity in space in which they exist by specifying the topological domain of its realisation as such a network*.' (Monico, n.d.)
The nine principles of the 'Hybrid Constitution' are available at the following address:
http://hybridconstitution.blogspot.pt/2011/11/9-auotopoietic-principle.html

This principle of Monico refers to the ambiguous nature of intermedia as a unit resulting from its own autopoiesis: the unity of the unique, the uniform, the conforming and the homogeneous, but also the unity of the shapeless, the diverse, the distinct and the heterogeneous. Coleridge in 1817 defined the *intermedium* as a catalyst, Cornock and Edmonds in 1973 considered the artist a catalyst of creative activity, and almost 200 years after Coleridge, in 2013, Ars Electrónica promoted an exhibition curated by Manuela Naveau, where the theme was precisely the artist and the work as catalysts. The timelessness of this association of the terms work of art and/or artist with catalysts gives it its constant relevance.

BACKGROUND AND (IN)CLASSIFICATION

Throughout history, there have been various artistic manifestations resulting from disciplinary crossovers, prior to the introduction of the concept of intermedia by Higgins. Youngblood (2011), referring to the growing ability of human beings to assimilate and understand increasingly complex environmental stimuli, considers the evolution of intermedia from primitive shadow plays to today's 'cybernetic phantasmagorias'. This longevity of intermedia suggested by Youngblood may be in agreement or related to Higgins when he suggests intermedia as a universal characteristic of the 'Fine Arts'. Wendt (1985), for example, refers to the proximity of certain sound poetry performances to evolving styles of intermedia performance, already since the 1950s. Peter Frank considers that some of John Cage's work from that decade, together with the Dadaist[48], Futurist and Surrealist antecedents, gave rise to a generation of artists interested in working between traditional artistic categories, creating not so much a combination of media in the Wagnerian sense of *Gesamtkunstwerk*, but rather an intermedia work in which, in its very conception, the different artistic categories cannot be identified or distinguished (Frank, 1974). In the following sections, artistic advances throughout history will be identified as antecedents of intermedia, relating them to what are considered to be properties of intermedia dynamics at the beginning of the 21st century.

'NON-TOTAL' WORK

In order to clarify the distinction between intermedia and multimedia in the Wagnerian sense, consider what Frank (1982) writes on this subject:

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48 *'Similarly, some of the first intermedia shows were put on by Dadaists in the twenties.'* (Shatnoff, 1967)

> Intermedia, in effect, denotes wholly hybrid art forms that result from the seamless fusion of approaches and attitudes originating in the traditional arts. The elements in Wagner's operas — music, libretto, dance, scenography and costumes (as they are) — can be functionally isolated from one another without total loss of coherence or integrity;[49] (p.58)

The *Gesamtkunstwerk* is therefore considered a multimedia work. As a combination of sound and visual arts, Frank (1982) places it in the category of works that merely superimpose one medium over another. He further states that '[the] referential crossover and combination of visual and sound arts are part of a comprehensive domain of cross-cutting and panoramic artistic activities that have remained for centuries. Multimedia manifestations comprise part of this activity'[50] (Frank, 1982, p. 58). Ox (1999a) refers to the complete difference between the concepts of intermedia and multimedia. For Ox, in multimedia, content is presented simultaneously in more than one medium, while intermedia combines structural and syntactic elements from different media into one. Higgins (1998) established a differentiation between intermedia and multimedia, considering the former to be a conceptual fusion[51]. Spielmann also contributed to the clear distinction between intermedia and other approaches such as multimedia, hypermedia or mixed media. The author argues that the latter are comparable to each other because they describe the 'expansion of a single medium in terms of accumulation', whereas in

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49 Translation by the author from the original: *'Intermedia, in effect, denotes the wholly hybrid art forms that result from a seamless fusing of approaches and attitudes originating in the traditional arts. The elements in Wagner's operas – music, libretto, stage design and costumes, dance (such as there is) – can be functionally isolated from one another without complete loss of coherence or even integrity; [...]*' (Frank, 1982, p.58)

50 Translation by the author from the original: *'The cross-referencing and combining of aural and visual art is part of a wide realm of cross-artistic and even pan-artistic activity which has existed for centuries. Multi-media manifestations comprise part of this activity.*' (Frank, 1982, p. 58)

51 One of the most common meanings of the word fusion includes liquefaction, melting and merging, the transition from a solid to a liquid state. In the context of this research, fusion is considered to imply fluidity. For example, Richard M. Poval also uses the term fusion to characterise his intermedia performance *'The Last Garden': 'The work is a fusion of experimental movement, music, video, visual design and* technology' (Poval, 1993, p. 25).

intermediation rather than accumulation, expansion results from a process of 'transformation'[52]. Although considered merely multimedia, Wagner's *Gesamtkunstwerk*, according to Wurth (2006), premeditated but did not achieve the total connection of all media in an amalgam without origin. In fact, according to Wurth, Wagner's approach affirmed the separation and hierarchisation between the media.

Wurth (2006) writes: Wagner's 'joint art' programme precisely feeds the medial limits: in his vision of the work of art of the future, Wagner starts from a hierarchy of the temporal ('Human') over the spatial ('plastic') media, and furthermore, he places each of these media within its conventional domain. Thus, painting, music, and poetry are juxtaposed rather than fused in the sense of combination, maintaining their respective functions. [53] (p. 7)

This point of view maintains that Wagnerian opera, oriented towards the proscenium, is not a transformative amalgam, a confusion of the arts and the senses or a contamination between media, but rather, and only, a combination of separate parts. Meier (2012, p. 134) calls the *Gesamtkunstwerk* 'non-total', because the media only collide with each other as multimedia dynamics, rather than interacting with each other as intermedia dynamics. Meier also distinguishes the *Gesamtkunstwerk* from intermedia, because in the former, the different media cooperate in a complementary way, aiming for totality, while in intermedia, what happens is precisely the deconstruction of the total work of art. Meier notes: 'it is in this sense that the *Gesamtkunstwerk* aspires to the total representation of human experience — the total work of art that must express all

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52 This is perhaps the main phenomenon that reinforces the intermediary's allusion to experimental chemistry as discussed in the section 'Higgins and Coleridge'.

53 Translation by the author from the original: *'For Wagner's programme of 'together-art' feeds, precisely, on medial limits: in his outlook of the artwork of the future he starts from a hierarchy of the temporal ('human') over the spatial ('plastic') media and, moreover, situates each of these media within their conventionally assigned domain. Thus, painting and music or poetry are not so much fused as put together in the sense of combining while retaining their respective roles*.' (Wurth, 2006, p. 7)
We suggest reading pages 182–195 of Richard Wagner's *The Art-work of the* Future, referred to in a footnote by Wurth.

life experiences, but does not create a new life experience.'[54] Meier's latter argument is of great importance in supporting the intermediality of the works resulting from the experimental part of this research project, since they aim to provide new experiences, expand the experiences lived by the audience and not make any kind of representation.

Although the distinction between *multimedia* and *intermedia* is clear, it is interesting to note the possibility of a relationship between these two practices. Glusberg (1980) considers that the multiplicity of media, *multimedia*, is the infrastructure of intermedia, conceived as the totalisation of artistic forms. This author sees intermedia as a total revolution in art and states that intermedia 'is not only *multimedia* but also *transmedia*'. Dias (2012), who also considers the opposition between the terms 'multi' and 'inter' in various [contexts], considers 'multi' as a statement of diversity and plurality. For Dias, 'inter' is a relational plane. This researcher suggests that multimedia 'comes' before intermedia and states that the relational character of intermedia has a constitutive role: '[...] the time of the relationship between the media is the time of production of the media themselves'. In other words, Dias maintains the idea that intermedia production is the production ([synthesis56]) of new media.

In a cultural context full of boundaries, Fornäs (2002) affirms the advantage of the relational aspect of 'inter' over the pluralism and combinatorial nature of 'multi':

> The generalist pluralism of the multi has its important points, but the relational aspect of the inter opens more doors.

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54 Translation by the author from the original: *'It is in this sense that the Gesamtkunstwerk aims at the full representation of human experience—the total work of art that should express all of life's experiences, but does not create a new life experience*.' (Meier, 2012, p.136)

55 Dias refers to these prefixes associated with media, culture and nationality: multimedia, intermedia; multicultural, intercultural; and multinational, international.

56 The synthesising nature of intermedia is presented in the section 'Affinity with chemistry'.

> broad to procedural cultural studies, allowing for a wider spectrum of diverse connections, beyond the mere addition of elements. This emphasises the inter as a way of navigating out of the traps of structuralism and systems theories, where dynamic relationships tend to be petrified into relatively closed totalities.[57] (Fornäs, 2002, p. 16)

Fornäs describes intermediality not only as relational, but primarily and precisely as a mixture of rule-breaking and the transgression of boundaries and limits. For this author, liberation from disciplinary restrictions is one of the necessary conditions for creative culture. For this author, multimedia are merely combinations of separable media, and Higgins' intermediality concerns 'the passages between media that require limits', for example, between their relative differences. From Fornäs' reading, it can be concluded that intermediality is also a 'field of intersection', a hybrid field of construction that operates in the overlap of what is separate and dispersed. This author's thinking highlights the consideration that these operations and mixtures 'of' and 'between' media require human agency and contextualisation. Media are related through contextualised human interaction.

> Intermediality (...) is when media (...) are connected by specific people (interpretive communities) in specific settings (physical, virtual, and social spaces). (...) People mediate.

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57 Translation by the author from the original: *'The general pluralism of the multi- has its very important points, but the relational inter- opens up wider doors toward new kinds of processual cultural studies, by allowing for a great range of different kinds of connection, beside the mere addition of elements. This stress of the inter- is a way to navigate away from the traps of structuralism and systems theory, where dynamic relations tend to become petrified into relatively closed totalities.*' (Fornäs, 2002, p.16)

58 The operationality of intetmedia at the thresholds of media will be discussed in the section *'Threshold* technology' in the chapter *'Practice*'.

59 'crossing-field'

> necessarily between media and media between people.[60]
> (Fornäs, 2002, pp. 19-20)

Still looking at artistic expressions resulting from disciplinary crossovers prior to the introduction of the concept of Intermedia, Eskilson (2003) refers to Thomas Wilfred's 1920s work 'Lumia'[61] as a work that precedes what would come to be called intermedia and, at the same time, as a work that validates modern technology as the material basis for some works of art. Invariably, artistic production resorts to one or more media, which, according to Oosterling (2003), are 'decisively structured by technical/technological apparatus'. It should be noted that this issue of technology as a material basis for artistic production suggested by Oosterling is also affirmed in the works resulting from the reflective practical research developed in this research project (ORIP) [63] and discussed in the section 'Reflective practice, Doing and Materials'.

FUTURISM AND DADAISM

Without the temporal distance of Eskilson, Kaplan, Cseres, Baker or Truckenbord, referred to in the previous section, Judith Shatnoff (1967) already considered that some of the early Dadaist performances in the 1920s were in fact intermedia. In the same year, Gilbert Chase (1967) pointed to Cage's work in the early 1950s as seminal for the development of what would come to be called intermedia, in at least two ways.

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60 Author's translation from the original: *'Intermediality and intertextuality is when media or texts are connected by specific people (interpretive communities) in specific settings (physical, virtual and social spaces). [...] People necessarily mediate between media and media between people*.' (Fornäs, 2002, p. 19-20)

61 For further information on the 'Lumia' project, see Jörg Jewanski's description available online at: http://www.see-this-sound.at/works/522

62 Translation by the author from the original: *'media are decisively structured by techn(olog)ical apparatuses' (Ooosterling, 2003, p. 36). It was decided to translate the term 'techn(olog)ical' as technical/technological because the parentheses within the word indicate its double meaning*. (Oosterling, 2003)

63 Given that it will be necessary to refer repeatedly to the works resulting from the reflective practical research developed in this investigation, in order to simplify the writing and reading of this thesis, the works in question will be identified by the abbreviation ORIP.

aspects: the suppression of musical notation, as an opportunity to open up the space-time of the work to the performer's action, and the occasional (sound) events generated in/by the environment. Kirby (1965) states that each of the dimensions of Cage's work was already foreshadowed in the work of the Futurists and Dadaists. As early as 1913, the Futurist Luigi Russolo wrote a letter/manifesto entitled 'L'arte dei rumori' — The Art of Noises, which Christensen (2009) considers to be one of the most influential texts on 20th-century musical aesthetics. In this manifesto, Russolo (1967), who wanted to radically change the perception of what music could be, expressed his desire for the noisy sounds of machines and urban life to be considered musical tones and timbres.

> In the pulsating atmosphere of large cities as well as in smaller, older and quieter ones, machines today create a great deal of varied noise that pure sound, with its smallness and monotony, fails to arouse any emotion.[64] (Russolo, 1967, p. 5)

In this sense, the Futurists already advocated an unapologetic attitude towards the use of any medium in artistic events. The Futurists were also well aware of the influence that technology, major scientific discoveries, and the media, transport and information would have on the renewal of human sensibility. According to Tisdall (1978b), Marinetti, fifty years before Marshall McLuhan, had already understood that in the world of expanding communication in the 20th century, the medium is the message: 'the way you say it is as important as what you have to say'[65]. In the same text, Tisdall states that the Futurists

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64 Translation by the author from Russolo's original text written in 1913: *'In the pounding atmosphere of great cities as well as in the formerly silent countryside, machines create today such a large number of varied noises that pure sound, with its littleness and its monotony, now fails to arouse any emotion.*' (Russolo, 1967, p. 5)

65 Adaptation by the author from the author's original writing:
'But more than this: fifty years before Marshall McLuhan, he had perfectly understood that, in the expanded world of twentieth-century communications, the medium is the message; that is, whatever you have to say, how you say it is as important as what you say.' (Tisdall, 1978b, p. 8)

The futurists turned their backs on the ‘closed’ life of the ‘intellectually cultivated’, which in a way can be considered an anticipation of the transgression and defiant attitude of intermedia towards institutional schemes and conventional definitions. Another aspect of the Futurist movement, which precedes what would later be practised by the Dadaists and integrates the concept of intermedia that this thesis seeks to uphold, is the use of the audience's instantaneous reaction.

> The essential thing was to engage an audience that was no longer considered passive and submissive. "We place the spectator at the centre of the picture," declared the Futurist painters in their manifesto, the expectation being that the spectator would not remain immobile but would react.[66] (Tisdall, 1978b)

According to Tisdall (1978a), Marinetti, in expanding the new form of performance, included a greater degree of audience participation. When he states that the Futurists glorified experimentation, possible or [impossible], much more than the results achieved, Tisdall (1978b) somehow supports and confirms what Janet Kaplan and Peter Frank said about valuing the process over the final result. In order to emphasise and uphold the experimental nature of intermedia, remember Oosterling (2003) when he states that intermedia is instrumental and that one of its fields of research deals specifically with the quality of the 'inter' experience, strengthened by intermedia artistic practices.

Like Russolo and his ‘L’arte dei rumori’, the ‘noisy aesthetic’ known as ‘bruitism’ explored by the Dadaists, according to Niebisch (2013), also

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66 Author's translation from the original: *'The essential thing was to involve a public that was no longer rendered passive and submissive. "We place the spectator in the centre of the picture", the Futurist painters declared in their manifesto, and the expectation was that the spectator would not just stand there but hit back.'* (Tisdall, 1978b, p. 8)

67 As an example of the possible or impossible experimentation of futuristic actions, Tisdall recalls the exploration and development of the senses achieved by Marinetti in his 'Manifesto of Tactilism'.

He also aimed to 'end chauvinism against noise'. Another of the Dadaist strategies that can be considered a precursor to intermedia was the use of the audience in such an extreme way that it was considered parasitic by Niebisch. This strategy is discussed in the section 'Audience, Indeterminacy and John Cage'.

Molesworth (2003) states that Dadaism was always open to revision and repetition, which he considers to be 'the eternal return'. According to Molesworth, this openness to revision and repetition is due to Dadaism's lack of coherence as an artistic movement that can be codified by art history. Foster (2003) even considers that one of the objectives of Dadaism was pandemonium, total confusion, a tumultuous place without rules. Kristiansen (1968) corroborated this idea of pandemonium as early as the 1960s. In his argument, which supports the fact that Dadaism was an unavoidable influence on the 'happening', he quotes Clau Backman, who uses precisely the same term: 'orgiastic pandemonium'. Kristiansen considered Dadaism to be the opposite of an artistic movement, as the rejection of all schools, born out of a need for independence and mistrust of unity. For Molesworth, Dadaism is more a set of heterogeneous strategies or production techniques that oppose specific aesthetic issues. The Dada strategies identified by Malesworth as most important were the 'invention' of the 'readymade', the use of collage, montage and the implementation of chance. These strategies are not only mechanisms for the materialisation of artistic objects, they are also renunciations of traditional forms of artistic work. Each of these inventions questioned

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68 Author's translation from Niebisch's original '*[...] but also the Dadaists intended to end this chauvinism against noise*.' (Niebisch, 2013, p. 2)

69 *'Such pandemonium (literally "abode of all demons; place of lawless violence or uproar; utter confusion") is one aim of the Dadaists.*' (Foster, 2003, p. 166)

70 The happening as a precursor to intermedia is discussed in the section *'Ready Made and Happening*'.

71 *Clau Backmann's description of a "happening" at the Aachen Technical School appears to be a decryption of the Dada exhibition of 1920 - "an orgiastic pandemonium of apparently senseless sounds and actions... for the express and avowed purpose of provoking opposition and revolt.*" (Kristiansen, 1968, p. 462)

72 The 'readymade' as a precursor to intermedia is discussed in the section 'Ready Made and Happening'.

profoundly the role, stability, nature and necessity of the artist's labour, by freeing the body from outdated artistic skills. Dadaism 'was the profound rejection of the production of objects with traditional artistic skills, in such a way that what is questioned is the problem of artistic work.'[73] Buying, editing, arranging, these were the new forms of work that were not yet as familiar and managed as they are today. Walter Benjamin congratulates the Dadaists in his controversial 1934 work 'The Author as a Producer', in which he points out as a revolutionary force of Dadaism 'the fact that it called into question the authenticity of art'[74] (Benjamin, 1934/2008). Even more challenging to traditional modes of artistic work were artists who used chance; whether it was a found object or an automatic drawing, chance allowed artists to relinquish final control over their works of art, thereby simultaneously diminishing the quantity and effect of their labour. According to Kristiansen (1968), Dadaism anticipated and influenced the 'happening' through its heterogeneous mixture of different forms of expression, and mainly through three of its theories: 'bruitism', simultaneity and spontaneity. The latter two theories are essential in the construction of the concept of intermedia and are effectively present in ORIP. In summary, in intermedia works in general, there is invariably a simultaneity of means to give shape to the work. By means, we mean any technical, human or conceptual resource. In the particular case of ORIP, in addition to the simultaneity of means, there is also the spontaneity of the participating spectator, acting without any prior guidance or staging.

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73 Translation by the author from the original: '*[...]. it was a profound rejection of the production of objects with traditional artistic skills, such that what is at issue is the problem of artistic labour.*' (Molesworth, 2003 p.187)

74 Translation by the author from the original: *'The revolutionary strength of Dadaism consisted in testing art for its authenticity.'* (Benjamin, 2008, p. 86)

75 *Most recently, the influence of Dadaism is evident in "total theatre," "happenings," and psychedelic art experiences. The technique of "total theatre" involves the use of multiple screen and light images in contrast to the moving actor and plastic forms. This heterogeneous mixture of different forms of expression approaches Dada theories of bruitism and simultaneity. The multiple space perspective of the stage designs for 'total theatre' productions appear alarmingly similar to many Dada paintings, which also advocate simultaneity in* structure.' (Kristiansen, 1968, p. 461)

THE THRESHOLD SPACE-TIME, BETWEEN THE MEDIA AND INTERSTITIAL OF INTERMEDIA.

Janet Kaplan (2000) confirms the antecedents of intermedia suggested by Peter Frank (Dadaism, Futurism, Surrealism and John Cage), emphasising the importance of the exploratory spirit, the desire to break down (disciplinary) boundaries and, above all, the value placed on the process rather than the final result of the works present in these artistic movements. Baker (2003a) refers to the Dadaist process as a structural activity and as a work of hybridisation. This author states that one of the important Dadaist strategies was precisely the war on categorisation and the development of a type of work 'between the media'. 'The black square was exhibited in a gallery. It was hung in a corner: between painting, sculpture and architecture simultaneously. The work also occupied a hybrid space, the space in between.' (Baker, 2003a, p.161).

This spatial notion, referred to in Baker's quote, of 'between' in relation to categorisation, is interesting, because this is effectively what it is about: when attempting to classify any of the ORIPs, it is difficult to categorise them as solely sculptural, plastic, musical, sonic or architectural. The three works produced do not fit exclusively into any of these categories, but also fit into all of them in some way. They are the product of interactions between independent systems in space and time (Ox, 2001). They occupy this hybrid and ambiguous space-time of intermedia. It is essential that the academic and scientific communities recognise and disseminate this space-time, otherwise the work of the intermedia artist/designer cannot be understood, and the awkwardness of the void persists when the artist is asked and questioned about whether their work is painting, sculpture or music, having

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76 The importance of Dadaism as a precursor to what would come to be called intermedia and its hybrid characteristic are discussed in the sections 'Futurism and Dadaism' and 'Holistic and Hybrid', respectively.

77 Translation by the author from the original: *'The black square was shown in a gallery. It was hung in a corner: between painting, sculpture, and architecture all at once. It too occupied a hybrid space, the space of the* between' (Baker, 2003a, p. 161)

difficulty in categorising it. Cseres (2009) also refers to Milan Adamciak's work, placing it in this space-time between media, codes, types, genres, forms, instruments and institutions. For Cseres, Adamciak's intermedia production transgresses and challenges conventional classifications, institutional frameworks, and conventional definitions of art and creativity.

In fact, the space-time that mediates between categories, between media, between concepts, is not empty; on the contrary, it is a space-time filled with possibilities, countless combinations and configurations. Fornäs (2002) refers to this intermediary space-time as a space-time of transgression, because the intermediary operation takes place precisely in the threshold zone between media, disciplines and concepts. To substantiate his idea of the threshold as a zone, space-time and not as a limit, border or division, Fornäs uses the distinction of threshold proposed by Walter Benjamin:

> The threshold must be carefully distinguished from the border. The *Schwelle* <threshold> is a zone. Transformation, passage and the action of waves are meanings that exist in the word *schwellen,* and the etymology should not forget these meanings.[78] (Benjamin, 1999, p. 494)

For Fornäs, thresholds are much more interesting because they allow passages, passages between 'spheres', states or environments. A threshold is a transition zone, and a border is a line that separates. Thus, according to Fornäs, borders inhibit movement and thresholds invite innovative change. In fact, these thresholds seem to be part of human nature, because according to this author, human communication and interaction

78 Translation by the author from the original: *'The threshold must be carefully distinguished from the boundary. A Schwelle <threshold> is a zone. Transformation, passage, wave action are in the word schwellen, swell, and etymology ought not to overlook these senses.*' (Benjamin, 1999, p. 494)

are recognised as sources of liminal experience. Perhaps for this reason, rather than studying and operating each type of medium in isolation, intermediaries investigate and explore their intersections within differentiated communication networks (Fornäs, 2002). Recent cultural research, replete with references to nomadic movements and the crossing of traditional boundaries, is justified, according to Fornäs, by the possibilities of modern communications, which allow 'people and their work to cross a growing number of boundaries, energising space-time by accelerating passages through physical spaces and social and cultural experiences'.

Still on this space-time of intermedia, Baker (2003b)[80], who calls it 'betweenness', seems to attribute elastic and flexible properties to it when he states that the definitions of media stretch/expand, considering that this expansion happens both 'between' and 'within' the media themselves. Meier (2012) states that this space, which he calls intermediate, 'has the potential to create genuine thought as an event within the concentration of intermedia artistic work.' In other words, the space-time of intermedia is both a space-time of thought and a space-time that generates thought. Meier also refers to this space-time, where disparate elements touch and merge into an amorphous whole, as a field of composition endowed with a self-built structure, constructed by dismantling the structure of fixed codes and static grids of conventional configurations. Meier considers that the cons-

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79 *'Practices of entertainment and popular culture as well as the various uses of communication media also induce several kinds of threshold states – between self and others, past and future, understanding and the unspeakable. The media play a fundamental role in the ritual processes that structure everyday life.'* (Fornäs, 2002, p. 4)

Translation by the author from the original: 'Practices of entertainment and popular culture as well as the various uses of communication media also induce several kinds of threshold states – between self and others, past and future, understanding and the unspeakable. Media play key roles in ritual processes that structure everyday life.' (Fornäs, 2002, p. 4)

80 'And *Charon's* forms of "betweenness" begin to stretch medium definitions as much as subjective states (…) The *mise-en-abyme* of images within Charon stretches between, not solely within mediums: here between photography and television, elsewhere between photography and theatre or photography and painting.'
(Baker, 2003b, p. 39)

81 Translation by the author of the original 'space in-between'.

82 Translation by the author from the original: '...has the potential to create genuine thought as an *event* within the concentrated form of intermedial artwork' (Meier, 2012, p. 125)

Translation in the ‘intermediate space’ creates tension, vibration and intensity, and furthermore emphasises that this seemingly empty space is not empty at all. Meier quotes Guattari to support his description of this space, stating that it is not ‘a neutral, passive, deficient point, but rather a degree of extreme intensification’.[83] At the end of the 1970s, Walter Branchi and Renato Pedio (Branchi & Pedio, 1979) considered intermediality to be an unusual format in which different codes operate together. For these authors, intermedia is not a matter of ‘perceptual over-detection’, but rather the exploration of a hidden territory underlying everything. This territory, normative of mental activity, is, according to the authors, an extremely articulated communicative space that encodes messages from different channels with unified signals. Regarding music and language in this space, Branchi and Pedio write the following:

> This space is distinct in itself but common to both [language and music], in an uninterrupted mental activity. "Intermedia" tends to bring to light this preliminary space, taken for granted but always hidden and silent. This network that is always working and has always existed in the brain: Intermedia tends to acquire it at the level of perceptual activity, tends to find and adopt its structure; and make it work through desire and inventiveness.[84] (Branchi and Pedio, 1979, p. 89)

Truckenbord (1992) seems to refer to this 'territory' when he criticises the existence in art of a separation and fragmentation of different modes

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83 Author's translation from the original: '... not a neutral, passive, deficient, negative point, but an extreme degree of intensification.' (Guattari, 1995, pp. 81-82)

84 Translation by the author from the original: ‘This space is in itself distinct but communal to both, in an uninterrupted mental activity. The "Intermedia" tends to draw to light that preliminary space, taken for granted but always hidden and silent. That network which is always at work and has been from the beginning buried in the brain: Intermedia tends to acquire it at a perceptible level of activity, find and adopt its structure; and make it work by willing and inventiveness.’ (Branchi and Pedio, p.89)

of human interaction, communication and expression, and when he considers that artistic work should incorporate all these modes. In his argument, he recalls Marshall McLuhan, who attributes to the invention of the printing press the increase in the segmentation of sensory perceptions and the consequent decrease in the ability to think and feel kinesthetically. Truckenbord also states that upstream of this separation, there is a complete interaction between sensory experiences, which he calls ‘integrated creativity’. Hence, according to the author, creative expression is an integrated process in which various combinations of elements are used for artistic expression. From Truckenbord's argument, it is interesting to highlight for the present research the fundamental idea that 'fragmentation inhibits the expression and communication that integrates our [sensory] experiences'.

Truckenbord thus advocates a space-time that can be associated with intermedia, integrated and integrating different modes of human interaction, communication and expression. Currently, Ascott (2013), in proposing the concept of ‘interstitial creativity’, refers to any practice that acts between the boundaries of media, genres or types of knowledge, without recognising any hierarchy between them. It can be concluded that at the beginning of the 21st century, intermedia dynamics operate precisely in this [interstitial] space-time, filled with matter and [structure].

85 The chapter entitled ‘Practice’ will discuss precisely the issue of writing and text as a phenomenon of fragmentation, considering it inadequate for the transmission of knowledge resulting from practical intermediate research.

86 Interstitial according to the definition found on Wikipedia at the following address: http://en.wikipedia.org/wiki/Interstitial

87 In the sections 'Holistic and Hybrid' and 'Limar Technology', the issue of intermedia space-time associated respectively with artistic language and technology is discussed again.

FLUIDITY, FLUXUS AND UNCLASSIFIABILITY

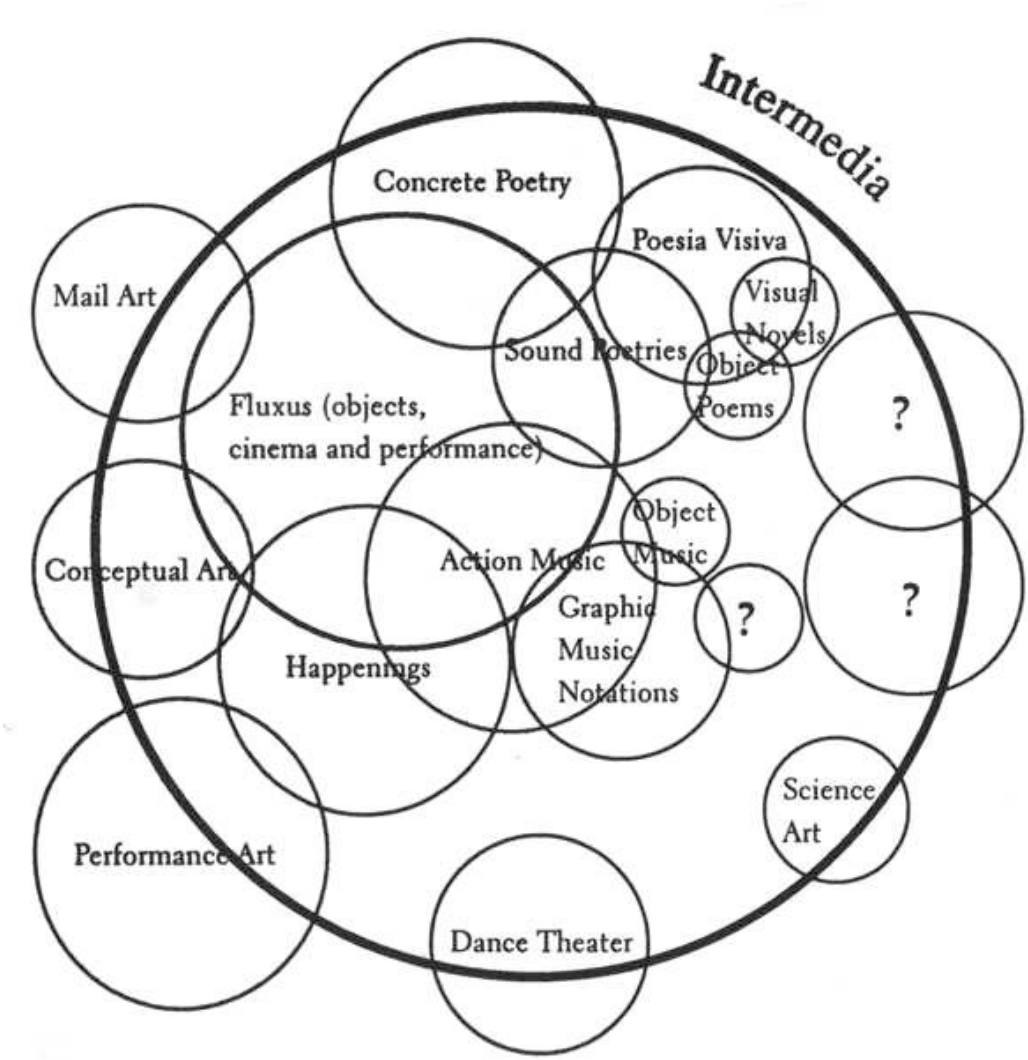

Figure 1. Intermedia Chart. Dick Higgins 1995.

The idea of fluidity can be seen as another of the most important attributes of intermedia. Kahn (1999) states that Cage and Pollock unleashed a fluidity in the arts in the 1950s that implied a sense of agency that was provocative and distinct from controlled social determination. The fluid interaction between different manifestations of information (Paul, 2002) is evident in the diagram proposed by Higgins in 1995 (see Figure 1). Higgins associates the name of the Fluxus movement with fluidity (Higgins et al., 2000) and states that this idea has been lost in much of what has been written about Fluxus because fluidity has only been considered in opposition to structure. Hanna Higgins

(2001) comments on the formal fluidity, openness and non-linearity of Higgins' diagram:

> The graph shows intersections between works from the Fluxus movement and related works, without establishing any linear chronology. Fluid in form, the graph shows concentric and overlapping circles that seem to expand and contract in relation to the Intermedia that frames them. It is an open structure that invites play. Its bubbles float in space rather than being framed historically in the specialised and linear art/anti-art perspective of the chronologies typical of the avant-garde and modern art.[88] (Higgins, H., 2001, p. 53)

Still on the subject of this diagram, Hanna Higgins (2002), in order to enhance the visualisation of fluidity, a characteristic of intermedia, complements the visualisation of the diagram by explaining that the bubbles in the diagram expand, contract, pass over and through each other.Kostelnatez (1999), who considered the overlapping categories in the diagram to be a representation of the interrelationships between the activities pursued by Higgins throughout his career, emphasises the importance of some circles in the diagram being marked with question marks, suggesting the existence of categories that Higgins himself was unable to name.

Wurth (2006) attributes fluidity to the media themselves, considering them to be fluid processes with no essential point of origin. Marranca (2006) states

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88 Author's translation from the original: "The chart depicts intersections between fluxus and related work and makes no attempt at linear chronology. Fluid in form, the chart shows concentric and overlapping circles that appear to expand and contract in relationship to the 'Intermedia' framework that encompasses them. It is an open framework that invites play. Its bubbles hover in space as opposed to being historically framed in the linear and specialised art/anti-art framework of the typical chronologies of avant-garde and modern art." (Higgins, Hanna, 2001, p. 53)

89 Hanna, in adding her comment and clarification, seems to consider that the diagram is a distortion of her father's idea because it is a static two-dimensional representation. In the context of this research, the inadequacy of language, in this case diagrammatic language, to express a concept or idea is proven.

spatial fluidity when he questions whether it is possible to distinguish between an installation, theatrical scenography, or interior design. According to Kase (2009), it is the fluid interaction of elements derived from different media that allows Nam June Paik to overcome the conventional limits and boundaries between these different media in an integrated and organic audiovisual form. Rogers (2011) considers that the 'exchange and transformation of elements from different media' referred to by Spielmann (2001) precisely defines a fluid fusion. Rogers associates this idea of fluidity with music and art, for example, when he states that, in the 20th century, these cannot be coherently considered as individual disciplines, but rather as a parallel historical path that moves fluidly between the space of both.[90] Already in the late 1970s, Ulmer (1977) considered this flow to be a paradigm shift implemented by the effort to break down the boundaries between disciplines and the arts.

Birringer (1999) stated the following:

> Since the movements in happening, body art, Fluxus, conceptual art and pop art in the 1960s, the integral change in the art paradigm, the blurring of boundaries and confluences between art, technology and popular media have broadened the spectrum of 'performance art' to a point where actions, happenings, events, concerts and installations could include any combination of (in)formal media or modes of presentation. This blurring of the notion of performance makes it difficult to reinvent aesthetic criteria

90 "Understood in this way, music and art in the twentieth century cannot coherently be discussed as individual disciplines, but rather encourage a more lateral history - or spatial sensibility - that moves fluidly through the space between them."
(Rogers, 2011)

> that delimit our understanding of the artistic process.[91]
> (Birringer, 1999, p. 366)

In fact, the 1960s, the heyday of the experimental events of the *Fluxus* phenomenon, the blurring of boundaries and the confluence between art and technology, were undoubtedly the context and pretext for Higgins to suggest intermedia as a 'more or less' universal characteristic of the Fine Arts. Higgins does not use the term to categorise, but rather suggests that it is a continuous mental issue that cannot be categorised: 'I would suggest that the use of intermedia is more or less universal across the fine arts, since continuity rather than categorisation is the hallmark of our new mentality.'[92] (Higgins, 1966b)

Higgins' idea of continuity (continuity between disciplines, knowledge, processes, ideas, skills and everything else) gives intermedia its fluid and hybrid character. This raises the question of whether it is possible to define or categorise intermedia. Higgins considers two possibilities: intermedia as a huge and inclusive artistic movement with roots in Dadaism, Futurism and Surrealism or, conversely, intermedia as an inevitable and irreversible historical innovation in reaction to the compartmentalisation of history itself. Also in the 1960s, Cage wrote: 'Art, if you want its definition, is criminal action. It does not conform to rules. Not even its own.'

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91 Translation by the author of the original:
'Since the 1960s movements in happening, body art, Fluxus, conceptual art and pop art, the entire paradigm of high art has shifted, and the blurring of boundaries and the confluences between art, technology, and popular media have widened the spectrum of "performance art" to a point where actions, events, concerts and installations could include any combination of media or (in)formal means of presentation. This blurring of the notion of performance makes it difficult to reinvent particular aesthetic criteria that delimit our understanding of art process.' (Birringer, 1999, p.366)

92 Translation by the author from the original: 'I would like to suggest that the use of intermedia is more or less universal throughout the fine arts, since continuity rather than categorisation is the hallmark of our new mentality' (Higgins, 1966b)

93 Translation by the author from the original: 'Art, if you want a definition of it, is criminal action. It conforms to no rules. Not even its own.' (Cage, 1969, p.51)

In a manifesto included in the pamphlet 'Great Bear Pamphlet'[94] , Kaprow (1966) implicitly denies the importance of categorising Art, affirming the imprecision and insufficiency of the written word as a tool for delimitation:

> [The word] 'Artist' refers to the person voluntarily involved in the dilemma of categories, and who performs [their activity] as if none of them existed. […] Precisely because art can be confused with life, it forces attention on the purpose of its ambiguities to 'reveal' experience.
>
> Philosophy will become progressively more impotent in its search for verbal knowledge, as long as it fails to recognise its own discoveries: that only a small fraction of the words we use have precise meaning; and only a small proportion of these contain meanings in which we are vitally interested. [...] When words alone are not a true index of thought, and when sense and nonsense today become quickly allusive and involved in implication rather than description, the use of words as tools to precisely delimit sense and nonsense may be a futile task. (Kaprow, 1966)[95]

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94 See "Great Bear Pamphlet" originally published in 1966 by Something Else Press. This pamphlet also includes Higgins' "A Something Else Manifesto".

95 Translation by the author from the original: '"Artist" refers to a person willfully enmeshed in the dilemma of categories, who performs as if none of them existed.
(…)
Precisely because art can be confused with life, it forces attention upon the aim of its ambiguities to 'reveal' experience.
Philosophy will become steadily more impotent in its search for verbal knowledge, so long as it fails to recognise its own findings: that only a small fraction of the words we use are precise in meaning; and only a smaller proportion of these contain meanings in which we are vitally interested. (...)
When words alone are no true index of thought, and when sense and nonsense today rapidly become allusive and layered with implication rather than description, the use of words as tools to precisely delimit sense and nonsense may be a worthless endeavour.' (Kaprow, 1966)

These words by Kaprow already support one of the major discussions in this research work: the insufficiency or inadequacy of words for recording, transmitting and expressing intermediate thought and knowledge. This discussion is explored in greater depth in the section ‘Tacit knowledge, explicit knowledge and theory without writing’.

Recent literature suggests that the need to create categories would be outdated by moving beyond media boundaries and due to the growing ambiguity and hybridity of the cultural environment in which we live today (McCombe, 2006). McCombe's description also fits a possible description of the intermedial experience. In the field of art, the boundaries between emerging artistic 'sub-genres' are becoming increasingly blurred. For McCombe, the growing availability and accessibility of technical means facilitates the crossing of artistic boundaries. According to the author, this availability and ease of use of certain media leads, for example, many musical composers to extend their [creative] practice by jointly exploring the visual field.

In recent decades, the digitisation of some media has also contributed to the anachronism of differentiation and notions of specificity (of media).In ‘Video: From Technology to Medium’, Spielmann states that when different media converge technically (as in the case of the digitisation of film, video and audio recordings), their differences cease to be of interest in critical debate (Spielmann, 2006). The hybrid nature of intermedia, like the semantic ambiguity of language,

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96 We note that in the text ‘Videomusicvideo—Composing across Media’, McCombe also considers creativity as practice. The question of practice is developed in section x of this text.

97 “So once the rubric ‘digital’ is introduced to video, there seems to be no need to talk about video and computer as distinct media.” Spielmann, Yvonne. “Video: From Technology to Medium.” *Art Journal* 65.3 (2006): 54–69. Print.

98 Ken Friedman also defines intermedia artworks as hybrids formed on the basis of different media. ‘…is used to describe artforms that draw on several media and grow into new hybrids’ (Friedman, 2002, p. 245).

Friedman, K. (2002). Intermedia, in: S. Jones (Ed.) Encyclopaedia of new media. Thousand Oaks: Sage Publications.

which is agreed upon by several authors, from Faulkner in [193099] to Sabatini in [2005100], may undermine the success of any attempt to define intermedia precisely and objectively. The difficulty of categorising and classifying intermedia is already supported by Kirby (1969), albeit in a limited way, when he defines intermedia precisely as an artistic practice that exists between prevailing definitions: 'One of the strongest trends in avant-garde art has been in the direction of what Dick Higgins called Intermedia — art that exists between prevailing definitions or that uses materials and concepts from two disciplines [...]'[101]. In a recent conversation, Hans [Breder] (Breder, 2011) states that Intermedia in its essence is nothing in particular, and Herman Rapaport, his interlocutor in this conversation, considers Intermedia as the non-differentiation between activities and knowledge: 'We both share this idea that all disciplines are the same thing. And that is already intermedia. There is no real difference between all these activities.'[103]

Based on the literature review in this section, we can foresee the possible futility of a research project that aims to define, categorise and delimit intermedia. This text, which associates and equates intermedia with experimental chemistry, identifies verifiable attributes of intermedia in the works resulting from the practical reflective intermedia research developed in this PhD, which does not recognise disciplinary boundaries, as it is a fluid transformative action that operates transformations in disciplines and media.

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99 *"That was when I learned that words are no good, that words don't ever fit even what they are trying to say at..."*

William Faulkner, "As I Lay Dying", Vintage Classics; New Ed edition (4 Jan 1996) p 171 and 173 100

"The language is subtle and ambiguous."

Arthur J. Sabatini, "Robert Ashley: Defining American Opera," *PAJ: A Journal of Performance and Art*, Vol. 27, No. 2 (May, 2005), pp. 45–60

101 Translation by the author from Kirby's original (1969): 'One of the strongest tendencies in avant-garde art has been toward what Dick Higgins has called "intermedia" — art that exists between prevalent definitions or makes use of materials and concepts from two different disciplines [...]'

102 A contemporary of Higgins who claims to have arrived at the term intermedia simultaneously and without Higgins' influence

103 Translation by the author from the original by Rapaport (2011): 'You and I share this idea that all the disciplines are the same thing. And that's intermedia already. There's really no difference between all these activities.'

This explains the resistance that the academic system has shown in accepting this practice as part of the curriculum, since intermedia does not fit into a system that traditionally seeks precisely measurability, stability and disciplinary categorisation [104].

TRANSFORMATIVE FUSION

The transformative action of intermedia, which brings about transformations in the media, requires an approach to phenomena associated with it: intersensoriality, adaptation, and syncretism. In 1968, two texts by Schechner address intermedia in the context of transformation and interaction between architecture, theatre, space, scenography and technology. Schechner (1968a) writes: 'The new aesthetic is constructed in a system of interaction and transformation, in the ability of all coherent elements to include contradictory parts.'[105] Brook and Ritchie (1970) select a series of texts on human sensory processes with the intention of serving as a reference and creative suggestion for artists who develop intermedia or intersensory work. It is worth noting the approach of these authors, who, from an experimental psychology point of view, bring intermedia closer to intersensoriality.

It is also essential to highlight the reference made to 'adaptation' as a temporal phenomenon of enormous aesthetic potential which, according to the same authors, has not been sufficiently researched. The three works resulting from the reflective intermedia practical research developed during this PhD are steeped in time. They are temporal works and also imply the adaptation of users whose action is simultaneously functional and aesthetic.

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104 These issues are addressed in greater depth in the sections 'Transmissibility of tacit knowledge, research in action, Design Research through Practice and objects as containers and generators of knowledge' and 'Reproducibility and memetics' in the practice chapter.

105 Translation by the author from the original: *'The new aesthetics is built on a system of interaction and transformation, on the ability of coherent wholes to include contradictory parts.'* (Schechner, 1968a, p.41)

functional and intentional. As a medium, the user has a functional value in the materialisation of the work and, at the same time, the system of which he himself is a part triggers his action, which is always intentional. It should be noted that in the context of the works referred to, the concept of adaptation extends to the user, the media and the artist himself.

Adaptation is also directly related to syncretism, which is another attribute of intermedia. Syncretic consciousness is a survival mechanism associated with cultural adaptation (Miller, 2012). At the end of the 1970s, Higgins (1979) stated that 'intermedia is necessarily syncretic'. Higgins writes: '[...] intermedia is necessarily syncretic. That is, it fuses elements from diverse wholes rather than allowing each element to remain simultaneously present, distinguishable, discrete, and potentially separable from the work.'[107] This qualification reveals a maturity of the term intermedia as well as its expansion and reach into 'diverse wholes'. Oosterling (2003) states that intermedia aims at the unity of art, as a symbiosis focused on the convergence of different media. In 1966, when he coined the term intermedia, Higgins seems to refer to media and concepts from the field of the arts. Thirteen years later, he expanded the syncretism of intermedia by referring to the inclusion of elements from other cultures and civilisations in the intermedia fusion.

Within the scope of this research, we propose the universality of intermedia syncretism, in the sense that it can accommodate and adapt in its fusion media, concepts and techniques from any area of human knowledge, any culture, any experience or any phenomenon. Ben-net (2007) refers to intermedia precisely as a 'trend in contemporary practice to operate *between* media (and between all types

106 Amundson (1996) considers that adaptation has always been related to the concepts of intention and function, which have clear applications in human actions and their artefacts and can also be intuitively applied to natural entities.

107 Translation by the author from the original: *'Turning to another area, the intermediaries are necessarily syncretic. That is to say, they fuse elements from various wholes rather than allowing each element to remain simultaneously present, distinguishable, discrete, and potentially capable of being separated out of the work.'* (Higgins, 1979, p.29)

of semiotic codes)'. Considering that the term 'implies more than the internal differentiation or mixing of media that occur in art', Bennett points out that intermedia postulates precisely a broad sphere of transdisciplinary operation open to aesthetic (and not only) intervention, materialised as an intersection of diverse practices, technologies, languages and sign systems[108]. Barth (1984) also sees intermedia as an intermediary between the traditional domain of aesthetics and artistic creation.[109] If Bennett referred to intermedia as a transdisciplinary operation, Berger (1980) considers the intermedia experience a process for transculturality. Berger, who also considers language (signs and symbolic mediation) a medium, also supports this almost universal and comprehensive view of the term *medium*. In addition to expanding the concept of *mass media* far beyond the media (such as the press, television and radio) to include means of transport (such as cars, trains and aeroplanes), industrial products (which construct our familiar environment), services (such as tourism) and mass models (Gross National Product), Berger coins the term *'few* media' to designate media of interest not only to small audiences, but to audiences that require a special culture or, as Berger calls it, a 'cultivated culture' (through literature, painting, sculpture, architecture, museums, exhibitions, concerts, etc.)[110]. Recalling Birringer, who referred to the emergence of a 'spectacular mixture of styles' (in a spectrum ranging from op art, pop art, minimalist art, conceptual art and random art to cinematographic, advertising, exhibition and sporting practices), intermediate practice can also be considered a 'process of mutual information' (Birringer, 1985, p. 222). A process of information, which in the context of the practical research developed in this PhD can also be a process of deformation, approaching modelling.

108 "Realised as the intersection of different practices, technologies, languages and sign systems, intermediality posits a broad transdisciplinary sphere of operation, open to – but not restricted to – interventions in aesthetic form."
(Bennet, 2007, p. 434)

109 'The intermedia arts, I would say, tend to be intermediary too, between the traditional realms of aesthetics on the one hand and artistic creation on the other.' (Barth, 1984, p. 66)

110 In the section 'Transmissibility of tacit knowledge, research in action, Design Research through Practice and objects as containers and generators of knowledge', an idea very similar to Berger's 'cultivated culture' will be discussed, considering that an intermedia culture is necessary to understand intermedia dynamics.

mutual means, as stated at the end of the previous section. This process of mutual modelling of means, which involves adaptation and inter-sensoriality, can be considered a transformative fusion that results in syncretism.

READY MADE AND HAPPENING

The idea of pure media, pure formats, is inadequate for the dynamics of intermedia. In 1966, Higgins revisited the concept of *intermedium* that Coleridge, in the context of poetic writing, associated in 1817 with experimental chemistry and coined the term Intermedia as a critique of the separation, distinction and categorisation of the media used in Art.

This 'almost mechanical' separation and hierarchisation, accentuated during the Renaissance[111], persisted at least until the 20th century and was associated with the division and subdivision of society into classes[112]. For Higgins (1966b), the rigid division of social classes was already completely irrelevant, just as he considered it unnecessary to observe art rigidly pigeonholed into one category or another, into one form or another.

Without mentioning the importance of the viewer's role in interpreting works of art, Higgins (1966b) criticises the impossibility of dialogue between viewers and traditional works of art and questions some artistic movements, his contemporaries, such as Pop Art or Op Art, stating that both are dead because they confine themselves, through the means they use, to the old functions of Art: to decorate and suggest grandeur. According to the author, Ready-made and Happening break the idea of pure means and formats.

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111 Peter Weibel refers to the 16th century as the moment when Architecture, Painting and Sculpture, which until then had the status of arti mechanicae (mechanical arts), achieved the status of arti liberales (liberal arts). (Weibel, 2006)

112 The issue of the hierarchy of arts and knowledge associated with social stratification is addressed in greater depth in the section 'Techné and Episthémé – from polarisation to hierarchy'.

> The *ready-made* or *object-trouvé* is, in a sense, an interlude, as it was not intended to conform to the pure medium, as is usually suggested, and therefore suggests a location in the field between the area of general artistic media and the area of life media.[113] (Higgins, 1966b)

In the first phenomenon, the *ready-made*, the subversion of the functionality of a medium, or if you prefer, the transformation of the functionality of a medium, is evident. For example, in relation to Duchamp's urinal, 'Fountain', Arensberg stated: 'A lovely form was revealed, freed from its functional purpose, so someone clearly made an aesthetic contribution'[114] (Arensberg, 1917). Molensworth (2003) states that Marcell Duchamp's research on the *readymade* definitively replaced the act of artistic production with the act of consumption by purchasing his ready-made sculptures. Duchamp's practice in 'Fountain' refers to the concept of 'prosumption', which is affirmed in this text as inseparable from current intermedia dynamics.

In the particular case of the works resulting from the intermedia practical research developed in this PhD, the researcher's tasks freely combine production, consumption and reuse of media. An example of this is the use of hardware (such as the microcontroller ar-

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113 Translation by the author from the original: 'The ready-made or found object, in a sense an intermedium since it was not intended to conform to the pure medium, usually suggests this, and therefore suggests a location in the field between the general area of art media and those of life media.'

114 Translation by the author from the original: 'A lovely form has been revealed, freed from its functional purpose, therefore someone has clearly made an aesthetic contribution.'

Walter Arensberg was an art collector, critic, and poet. His commentary on Duchamp's work was found on Eduardo Kac's website. http://www.ekac.org/ottinger.english.html

115 'Marcel Duchamp's investigation of the readymade definitively substituted the act of (artistic) production with consumption, purchasing his sculptures already made.' (Molensworth, 2003, p.179)

116 'Prosumo' should be understood as associated with the notion of prosumer. The term may result from the contraction of the words professional and consumer, but also from the contraction of the words producer and consumer. Kotler (1986) considered 'prosumers' to be consumers who produce goods and services for their own consumption. In the context of this research, the term is intended to be used in a broader and more hybrid context: as a consumer who produces not only for their own consumption.

duino[117]) and software (such as programming environments and languages), both uses are simultaneously acts of production and consumption. Both an 'Arduino' and a programming language can be considered 'ready-made', ready for consumption, and indeed they are, but at the same time they also involve production. Both an 'Arduino' and a programming language serve the artist in configurations that were not foreseen by their respective authors and producers. Integrating an 'Arduino' and a programming language into a work of art requires production, understood as the construction of a programme using the programming language and the construction of an electronic system that includes the Arduino.

Still on the subject of the urinal, Duchamp himself wrote, 'He took an ordinary everyday object, placed it in such a way that its utilitarian meaning disappeared under a new title and point of view
— he created a new thought for that object.118' Duchamp subverts the functionality of the means he decides to use. Similarly, intermedia is also the liberation and subversion of the means from their original functions. It is the possibility of creating new thoughts, ideas and functions for existing means. This attribute of intermedia will be referred to later in the written rationale explaining the process of conception and elaboration of the three works resulting from the practical intermedia research developed in this PhD, as the transformation of the functionality of objects, materials and languages was part of the process of creation and materialisation of these works.

We could speculate that this ability to transform the functionality of objects is one of the characteristics that distinguishes human beings.

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117 Arduino is a platform for electronic prototyping. For more information, see: http://arduino.cc/

118 Translation by the author from the original 'He took an ordinary article of life, placed it so that its useful significance disappeared under the new title and point of view - created a new thought for that object.' Consulted in: Harrison, C., & Wood, P. (Eds.). (2003). *Art in theory, 1900-2000* (2nd ed.). Wiley-Blackwell. (p. 252)

from [the] other [animals]. At the turn of the 20th to the 21st century, Schneider (2000) introduced the term ‘nomadmedia’ into the artistic, political and social lexicon, referring to the nomadisation of the media. Although it was introduced in a context of political, social and artistic activism, this term seems to be very useful for denoting the liberation and subversion of existing media in intermedia practice. In the context of this research project, the nomadisation of media could be defined as the process of shifting media from their original contexts and functions to operate in other contexts. Although there are few literary references to this term, it seemed appropriate to include and disseminate it in this study, both as an autonomous concept and as an integral part of intermedia, but mainly because of its topicality.

In the second example, Higgins refers to the inclusion and participation of the spectator in what came to be known as a 'happening'. In this context, Higgins highlights the work of Kaprow [120] as a precursor to this type of artistic event, referring to his philosophical approach to mediating the relationship between the spectator and the work of art.

> Kaprow, more philosophical and restless, meditated on the relationship between the viewer and the work. He placed mirrors in his objects so that the viewer could feel included in them. As this was not sufficiently physical, he made immersive collages that surrounded the viewers. He called these works 'environments'. Finally, in the spring of 1958, he began to include living people as

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119 The use of tools or means is not exclusive to humanity; several animals also do so. Dolphins, otters, elephants, birds, and octopuses are some examples of animals that use tools to assist in certain tasks. For example, some primates use branches or stones to perform tasks related to obtaining food. We can distinguish humans from other animals by their ability to combine materials to build new functional objects (means) and by very often subverting functionality. of these objects. For example, a pencil, which is made from at least two materials (graphite and wood), serves a dual purpose: writing without dirtying your fingers. But the dual function of the pencil is quickly expanded and subverted when new functions are assigned to it, such as a bookmark or even a hair clip.

120 1927-2006

> part of the collage, and he called this 'happening'.[121] (Higgins, 1966b)

Higgins (1966b) criticises the format of traditional theatre, with its mechanical division of actors, production staff, separate audience, plot and script, for its lack of portability and flexibility. Declaring war on the script, he does not see improvisation as an alternative, and introduces variability and change into the structural elements of his theatrical creations. This criticism of traditional theatre, which he calls *'pros-cenic* theatre', can be associated with almost all stage performances, if one considers the separation of the audience.

> Therefore, Happening developed as an interlude, an unexplored territory between collage, music, and theatre. **It is not governed by rules**; each work determines its own medium and form according to its needs. **The concept itself is better understood by what it is not than by what it is**. (Higgins, 1966b)[122]

Still from the perspective of the impossibility of an objective definition of what intermedia is, it should be remembered that Higgins confronts two possibilities: Intermedia as a huge and inclusive artistic movement with roots in Dadaism, Futurism and Surrealism or, on the contrary, Intermedia as an inevitable and irreversible historical innovation in reaction to the compartmentalisation of history itself. At this stage of literature review and

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121 Translation by the author from the original: 'Kaprow, more philosophical and restless, meditated on the relationship between the spectator and the work. He put mirrors into his things so the spectator could feel included in them. That wasn't physical enough, so he made enveloping collages which surrounded the spectator. These he called "environments." Finally, in the spring of 1958, he began to include live people as part of the collage, and this he called a "happening."' (Higgins, 1966b)

122 Translation by the author from the original: 'Thus the Happening developed as an intermedium, an uncharted land that lies between collage, music, and the theatre. It is not governed by rules; each work determines its own medium and form according to its needs. The concept itself is better understood by what it is not, rather than what it is.' (Higgins, 1966b)

Without considering literature subsequent to Higgins, it is appropriate to summarise the characteristics of intermedia that seem to best support the work that results in ORIP: the transformation of the functionality of the media, the inclusion of spectators in the work of art and the mediation of their relationship with the work, and, not least, the inseparability of the time factor from the work of art.

As mentioned above, Higgins introduced the term Intermedia in February 1966. The following month, in March, Alan Kaprow (1966) used the term again, associating it with the terms fusion and hybridisation as parallel forms of thought closely related to the modern mental life of the time. This was the second written record of the term Intermedia, appearing in a manifesto included in the Great Bear Pamphlet[123], also published by Something Else Press. The immediate impact that both the readymade and the happening or Intermedia had on the artistic context was considerable. In the same year, Corrigan (1966) immediately referred to the intermedia experience and the happening as the harbinger of new and different forms of expression that no one could predict how they would evolve. Almost 50 years later, the questions and motivations of the *readymade* and the *happening,* explored by intermedia*,* remain open and current.

Having referred to the inclusion of the audience, both in futurist and Dadaist works and in happenings, as a resource for the materialisation of the work, and given that the works resulting from the practical research developed in this PhD also integrate the audience, it is necessary to discuss the importance that the audience has in the results of this research.

The happening will be addressed again in the following section, in the specific context of the indeterminacy of the intermedia work, in which the inte-

123 See "Great Bear Pamphlet" originally published in 1966 by Something Else Press. This pamphlet also includes Higgins' "A Something Else Manifesto".

the audience as a medium in the intermedia work, and how the audience confers indeterminacy on the work.

AUDIENCE AND INDETERMINACY

Since performance is an indisputable antecedent of intermedia, the latter inherits indeterminacy as a predominant element. In the decade in which the term intermedia was coined, it was often used in the context of theatrical design and production. Burnham (1986) even uses the term to define the practice of performance, of time-based or non-static arts, considering its definition so broad that it includes work from the opposite ends of any spectrum [imaginable]. Richard Schechner (1968a), on the other hand, positions intermedia on a continuous spectrum of theatrical events that ranges from traditional theatre to public events or demonstrations. In this 'spectral' reference, intermedia appears on the side of the spectrum where, according to the author, [textual] analysis is not possible. Schechner refers to the 'invitation' made to spectators to become part of the work, making it difficult to distinguish between performers and [spectators]. Another factor identified by Schechner is the inclusion of existing architectural spaces in the work. In the three works resulting from the reflective practical research developed in this PhD, the inte-

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124 'What is performance art? I have been asked so many times to define the term, and I find that it can be done only in a most general, non-specific way. We may call it time-based and non-static and intermedia art, but what we have is a definition so broad that it includes work at the opposite ends of any spectrum you care to name. I might as well be asked to define art itself.
Within performance art are all art movements, all art styles.' (Burnham, 1986, p. 15)

125 Schechner also bases his argument on the fact that intermedia knowledge cannot be classified or described in words, as has been mentioned throughout this thesis and will be discussed in the section 'Tacit knowledge, explicit knowledge and unwritten theory'.

126 In fact, Richard Schechner's text is an essential reference for this research, as it recognises the fundamental importance of including the audience in the work in the materialisation of some intermedia works.
"In many intermedia performances, the spectators actively participate. Often the entire space is a performing space; no one is just watching.
(...)
In some intermedia and environmental theatre, the audience is invited to participate. In events on the far left of the performance continuum, it is difficult to distinguish audience from performers.
(…)
The exchange of space between performers and spectators, and the exploration of the total space by both groups, have not been introduced into our theatre by ethnographers.
Richard Schechner 1968

The participation of both spectators and architectural space in the works is a constant. Recalling the spectrum proposed by Schechner, intermedia is close to the extreme where the author locates what he considers to be ‘non-matrixed performance’[127]. Considering a matrix as a mould, form or starting point from which something is generated, the absence of a matrix may give intermedia part of its indeterminate and indeterministic character. Kirby (1965), who discusses the issue of 'non-matrixed performance', confirms indeterminacy as a fundamental element of the performing arts.

> A final consideration about performance in new theatre concerns the issue of improvisation and indeterminacy. Indeterminacy means that the limits within which performers are free to decide are provided by the creator of the piece: a spectrum of alternatives is made available from which performers can select.”[129] (Kirby, 1965, p. 33)

It is worth noting the use of the term intermedia associated with indeterminacy, still in the context of performance, in a text in which Schechner (1968b) refers to the indeterminacy of the interrelation between the work and its spatial context. In the present research, indeterminacy is considered one of the strongest concepts associated with Intermedia. Kirby (1965) refers to the acceptance of incidents, occasional reactions from the audience or occurrences in the context of the work as part of the production of the work itself. Cage, in what is perhaps his most

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127 Michael Kirby (1965) upholds the concept of 'non-matrixed performance' in his text The New Theatre when he discusses precisely the differences between 'matrixed' and 'non-matrixed performances'.

128 “One final point about performance in the new theatre concerns the question of improvisation and indeterminacy. Indeterminacy means that limits within which the performers are free to make choices are provided by the creator of the piece: a range of alternatives is made available from which the performer may select.”
Kirby 1965

129 “One final point about performance in the new theatre concerns the question of improvisation and indeterminacy. Indeterminacy means that limits within which the performers are free to make choices are provided by the creator of the piece: a range of alternatives is made available from which the performer may select.”
(Kirby, 1965, p.33)

The controversial musical composition 4’ 33’’[130] embraces chance and indeterminacy by allowing any occasional incident (a cough in the audience, the creaking of a chair) to be integrated into the composition of the music, making it unique in each performance. Schechner (1967b) compares the indeterminacy conferred on the work, by integrating the audience and any other element of the context in which it is presented, to an accident when he writes: "The theatrical space is looking for the flexibility of electronic manoeuvring, the possibilities of film editing, the mobility of the audience in an accident on the street."[131] The same author, in a 1968 text, also considered that at the end of the 1960s, the interaction between performer and audience in stage shows had been very poorly explored and described this interaction as an exchange[132]:The ultimate exchange between performers and audience is the exchange of space, the use of the audience as both makers and observers of the scene." [133] In the same text, Schechner alludes to the vision of this new relationship between audience and performer already envisaged in many of the unrealised projects of the Bauhaus and Frederick Kiesler in the 1930s. 134 In the same year, Kristiansen (1968) already refers to the ‘countless variations of spectators’[135] considered by the Dadaists[136] in their assertion of independence and freedom. In fact, the Dadaists involved spectators as performers in a way that Niebisch (2013)

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130 Image of Cage's score: http://www.mitpressjournals.org/action/showImage?doi=10.1162%2Focto.2009.127.1.77&iName=master.img-003.jpg&type=master David Tudor. Reconstruction of John Cage's original score for 4'33" (1952). 1989. Courtesy of William Fetterman. http://www.mitpressjournals.org/action/showImage?doi=10.1162%2Focto.2009.127.1.77&iName=master.img-001.jpg&type=master Cage. Text version of 4'33" (1952). 1958–60. © 1993 by Henmar Press, Inc. Used by permission of C.F. Peters Corp. http://www.mitpressjournals.org/action/showImage?doi=10.1162%2Focto.2009.127.1.77&iName=master.img-002.jpg&type=master Cage. Graphic score for first movement of 4'33" (1952). 1953. © 1993 by Henmar Press, Inc. Used by permission of C.F. Peters Corp.

131 “Theatre space is seeking the flexibility of electronic manoeuvring, the montage ability of film, the audience mobility of an accident on the street.” Schechner (1967b)

132 In the context of this research, particularly in the works developed as case studies, this interaction is explored and affirmed to such an extent that it results in maximum concentration, i.e., the performer and audience become one.

133 “The final exchange between performers and the audience is the exchange of space, the use of audience as scene-makers as well as scene-watchers.” Schechner (1968a)

134 See ‘6 axioms for environmental Theatre by Richard Schechner’ (1968a) page 51.

135 ‘Dada was born of a need for independence and distrust toward unity. Dadaists cling to their freedom because the world, according to their view, is not specified or denied – it belongs in the innumerable variations of the spectator.’ (Kristiansen, 1968, p. 458)

136 See the section on Futurism and Dadaism, which explains how these two artistic movements preceded intermedia.

considered highly parasitic. According to Niebisch, artists sent a minor stimulus to the communication channel, just an 'irritating impulse'. As a provocation, this impulse elicited a response from viewers that was invariably stronger than the initial impulse. Niebisch refers precisely to an amplification: '... a stimulus created by Dada noise initiated a cyclical feedback; the provocations on stage aggressively involved the audience, who projected them back onto the stage. This dynamic triggered a circle that amplified the force and complexity of the Dada performance by including a multiplicity of new performers, namely the spectators. They no longer behaved like a contemplative theatre audience, but instead included themselves — as an enraged crowd — in the performance, or in more technical terms, constructed an amplification system based on feedback'.[137]

For Niebisch, this amplification was done in a parasitic way, as described above, taking advantage of the audience. Niebisch himself believes that the Dadaists would never have been able to create such amounts of energy without the participation of the audience. It is interesting to highlight the relationship between 'provocation' and amplification by placing it in the context of ORIP. This relationship is present and evident in these works. All of them provoke the viewers' action in some way, that is, their participation, and are therefore provocative. Consequently, the works, which do not happen without the viewer's participation, and the intentions of the author, the meta-creator, are amplified in various ways by the unpredictable action of the viewers. In the case of Greenray in particular, the work is amplified both by the individual and social dimensions of the viewers, who may or may not know each other beforehand. The work is amplified by pre-existing social and emotional ties/interactions (in the case of the participation of small groups

137 Translation by the author from the original: 'Thus, a stimulus created through Dada noise initiated a feedback loop; the provocations on stage aggressively engaged the audience, who projected them back onto the stage. This dynamic started a circle that amplified the force and complexity of the Dada performance by including a multitude of new performers, namely the spectators. They no longer acted as a contemplating theatre audience, but rather included themselves—as an angry mob—in the performance or, in more technical terms, constructed an amplifier system based on feedback.'
(Niebisch, 2013, p. 2)

friends) and, at the same time, it also fosters new social and emotional interactions (in the case of people who meet while experiencing and acting in the work[138]). Unpredictability and indeterminacy are therefore amplified in an incalculable way, as the work triggers human interaction in a process of discovery and exploration of a new environment or a new configuration, and this happens in the greenray light tapestry. To support the previous idea, we started from the principle recalled by Barret (2002) that there is too much indeterminacy in human interaction, reinforced by Vranas (2005) when he states that 'most people are indeterminate'. In this sense, it can be speculated that the interaction, always indeterminate, of a set of indeterminate agents (spectators), triggered by the integration of these agents into the work of art, results in the exponentiation of the indeterminacy of the work itself. A third indeterminate element can be added to this exponential process: the indeterminate possibilities allowed by the spatio-temporal configuration of the work as context, medium, tool or instrument. Semin (1998), in addition to establishing an equivalence between language and tool, emphasises precisely this indeterminacy of the possibilities allowed by the use of any tool, medium or instrument. Thus, the ‘operation’ of the indeterminacy of the work results from the interaction of at least three indeterminate elements: the spect-

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138 Schechner (1968a) even states that an audience is an improvised (and therefore indeterminate) group that happens to be present at the performance venue and will never meet again as a defined group.

139 Greenray is one of the works resulting from the intermedia research developed in this PhD thesis and is presented in the chapter ‘Green-Ray’.

140 Semin refers to verbal language, but in the context of this research, we have expanded Semin's considerations to any type of language, from visual language to sign language or any computational language.

141 "Therefore, while it is possible to list the properties of a hammer, its uses are indeterminate (such as extracting or inserting a nail, as well as breaking a window or killing a person). The indeterminacy of the possibilities allowed by the tool has a number of important consequences. Tools, in the hands of a master, can create a chair, a table or a cottage, but given a different cultural context or another master, the same tools will result in different 'functional' products, such as a pagoda, for example. And even within the same
culture, the same tools will produce different results and different products depending on the intentions, desires, and objectives of the person who is
helps these tools.”

Translation by the author from the original: ‘Thus, while it is possible to list the properties of a hammer, the uses that it can be put to are indeterminate (such as extracting and inserting a nail, as well as smashing a window or killing somebody). The indeterminacy of tool affordances has a number of important consequences. Tools, in the hands of one master, can create a chair, or a table or a chalet, but given a different cultural context or a different master, the same tools will result in different 'functional' products like a pagoda, a Chinese bridal cabinet, etc. And even within the same culture, the same tools will yield different outcomes and different products as a function of the intentions, desires, wishes and goals of the person who is availing him or herself of these tools. (Semin, 1998, p. 6)

indeterminate creator, the indeterminacy of human interaction and the indeterminacy of the possibilities of using a medium (and/or the work as a medium).

Ross and Nightingale[142] (2003) refer to Richard Butsch's demonstration that 'media presuppose the body' and assert that the relationship between bodily sensitivity and media illustrates a reconceptualisation of radical cultural production, as well as the role of audiences. Based on this thinking, it can be said that the intermedia works resulting from the practical research developed in this PhD, in addition to being amplified by the viewer(s), also amplify the sensory dimensions of the viewers' bodies.

Higgins (1979) also emphasised the active role of the audience:

> It is clear that there has always been a certain sense of change in the meaning of a work, a change in the way the public experiences this or that work throughout its history. But in recent works, as I mentioned, the public is encouraged to have an active rather than a passive mental attitude, seeing the work not only as it occurs but also imaginatively projecting alternatives.[143] (P.32)

Paul Hertz (1999) refers to Scriabin's work in the early 20th century as a counterpoint to the Wagnerian trend (which distances the mechanisms

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142 These authors study how human bodies are involved in the use of media, reflecting Butsch's thinking on the impact that 'new media' have on older ones and how new ways of 'being an audience' can reactivate old patterns of engagement or provide adaptations of (current and old) modes of interaction. We suggest reading the section 'Human bodies and mediatisation' in the book 'Media and Audiences'.

143 "Of course there has always been some sense of the change of meaning of a work, the shift in how an audience has experienced this or that work through its history. But in the recent works I have mentioned, the audience is encouraged to be active-minded rather than passive, and not only to see the work as it is taking place, but to project, imaginatively, alternatives as well."
(Higgins, 1979, p. 32)

behind the scenes of the show) by seeking to dissolve the boundaries between the audience and the work. Hertz states that for Scriabin, the confluence of sensory stimuli was the key to breaking with the Wagnerian tradition.

Based on the reflective practical research carried out during this PhD programme and on the literature review, it can be concluded that the behaviour of the audience and users of works of art is always unpredictable. The reactions and actions of the audience/users are part of the work of art itself, giving it part of its indeterminate character. Indeterminacy may be a cross-cutting quality in the field of art, but it is undoubtedly intermedia. Packer and Jordan (2001) seem to consider that indeterminacy in the work of art is also sustained by the integration of the audience into the work when they write that 'Cage embraced indeterminacy as an integral part of his compositional process; this technique led him to include audience participation in the creation of his work.'[144] Hannan[145] (2006) refers to the unpredictability of audience movements and the variability of these movements as key elements of indeterminacy. For Ros Bandt (2006), the density of the audience, being variable, is an important factor in shaping the artwork, becoming one of the main controllers of the form of many installations. In the particular case of [the GreenRay][146] installation, the density of the audience is undoubtedly the main factor shaping the appearance of the work. Indeterminacy as a quality is reaffirmed by Bandt when she considers her work to be an 'open work':

> This freedom for the audience to engage with the artwork in various ways was one of the reasons why I created sound installations with an open-ended form. When

144 "Cage embraced indeterminacy as an integral part of his process of composition; this technique led him to include the participation of the audience in the creation of his work."
Packer and Jordan (2001)

145 See Hannan (2006) on pages 331 and 336.

146 One of the works resulting from the reflective practical research developed in this PhD, which is presented in the chapter 'GreenRay'.

> If the audience is given the freedom to interfere, respond or create in the work, then its results become even more complex and unpredictable.[147] (P.356)

Humberto Ecco[148] (1962) stated that all works of art are open and indeterminate because they contemplate the diverse interpretations of their audience. Ecco's statement is contemporary to the height of the Fluxus movement, whose production is defined by its 'founder', George Maciunas, as a subtle, inexact art that invites invention and humour on the part of both performers and audience.[149] (Frank, 2005, p.30)

In addition to interpretations, the integration of the audience's own actions into the work, which transforms that audience into performers, as already mentioned, exponentially expands the indeterminacy of the intermedia work. Garwood (2007) uses the expression 'public ensemble'[150] to refer to works such as John Cage's 'Variations VII' because they simultaneously choreograph the positions of the artist, the performer and the audience. The composite of individual 'stories' and experiences of each member of the audience, which is confronted in an intimate relationship between the work (performance or installation) and the audience, as suggested by Barton (2008), is considered in this research to be one of the major drivers of indeterminacy in the intermedia works resulting from this research, as well as in intermedia works in general. Barton (2008) affirms the ambiguity and indeterminacy of intermedia: 'The "space" to which the intermedia performance invites its audience is, in

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147 "This freedom for the audience to engage with the artwork in many ways was one of the reasons I found myself creating sound installations with their open-ended form…Once the audience is given freedom to interfere, respond or create in the work, then its outcomes become even more complex and unpredictable." (Bandt, 2006, p.356)

148 Ecco's 'Open Work' (1962) is a highly topical work contextualised in the most effervescent moment of the Fluxus, Neo-Dada and Happening movements.

149 'Until his death in 1978, George Maciunas, the "founder" and principal organiser of Fluxus, preferred to keep Fluxus art in this mode: subtle, inexact, inviting invention and humour on the part of both the performers and the audience.'
(Frank, 2005, p.30)

150 'public ensemble'

so complex, multifaceted, contradictory and ambiguous.'[151] Kase (2009) uses Yoko Ono's work 'Cut Piece' as an example of (in)determinacy, in which Ono provides a pair of scissors for the audience to cut her clothes. According to Kase, 'ultimately, the development of the work (the audience's interaction with Yoko Ono) and its final outcome (how much clothing she would be left wearing) were entirely determined by the choices made by the audience.'[152] Another example used by Kase is Carolee Schneemann's work 'Interior Scroll'. In this example, Kase distinguishes the passivity (of the audience) in a film experience from more unpredictable and uncontrolled behaviour in the face of performance. Mary Beth Edelson[153] states that in her 'public rituals' she used tensions (among the audience) as a vehicle to disrupt stability and create unease.

> I am encouraging the performers and the audience to participate in a reciprocal connection during the short life of the performance [...] To get the audience to become participants in this collective experience, it is necessary to establish trust as well as the belief that this is a substantive experience (...) It is the participants' own will that dissolves their personal barriers, establishing a platform for transfers.

151 "The 'space' into which an intermedia performance invites its audience, then, is a complex, multifarious, contradictory, and ambiguous one." Barton 2008

152 Translation by the author from the original by Kase (2009):
"Ultimately, the performance of the piece (how the people interacted with Ono) and its final outcome (how much clothes she was left wearing) were entirely determined by choices made by the audience." (p. 108)

153 Mary Beth Edelson (cited in Intermedia: Enacting the Liminal edited by Hans Breder, Klaus-Peter Buss) P.165

alchemical powers to ritual potency.[154] (Edelson, 2005, p.165)

It is worth noting this reference to alchemy, which refers to the field of chemistry, a field used by Coleridge when he introduces the term ‘inter-medium’. This reference also supports the affinity between intermedia and chemistry, as discussed above.

Popper (2007) sees spectator participation as a relationship between public participation and the artist's responsibility. In his analysis, he questions whether this participation is calculated by the artist; whether, on the contrary, the notion of participation lies in the equivalence between the sensibilities of the artist and the spectator, or whether the invitation to participate aims at the reinvention of art by the spectator.

However, the most pertinent hypothesis for this author is that the invitation to participate aims only to allow the viewer to experience freedom. Popper also refers to two further aspects that are considered fundamental in supporting the three works resulting from the research carried out during this PhD: the 'determination to share the creative act with the public' and the production of 'manipulable works that aim at randomness and ephemerality by creating situations that are in constant flux'.

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154 “In my public rituals I have made use of tensions as a vehicle that disrupts stability, creates uneasiness and encourages a shift in position. The building of this tension is simultaneous with easing just enough to keep the participants from withdrawing from the encounter.
[...]
I am encouraging the performers and the audience to participate in connecting with each other during the brief life of the performance. (…) To incline the audience to become participants in this collective experiment, trust needs to be established as well as the belief that this is a substantive experience, worthy of risking letting go. It is then the participants' own willingness to dissolve their personal barriers that sets the stage for an alchemical transfer of power to the ritual's potency. (Edelson, 2005. p.165)

THE AUDIENCE AS A MEDIUM.

Robinson (2009) reaffirms the idea that audience participation contributes to the indeterminacy of the artwork when he writes about John Cage's "silent piece" as a concise model of chance and indeterminacy, stating that Cage "handed over some of the power of creation to the audience." In fact, and still according to Robinson, the active inclusion of the public in the creation, production and presentation of the work structures the 'separation' identified by Duchamp between creator and receiver. In ‘A imaginação cega’ [Blind Imagination], Leal (2009) recalls the 1957 conference ‘The Creative Act’, where Duchamp presented the idea that:

> [A] “aesthetic osmosis” between the work, the author and the viewer is achieved through the intersection between the materiality of the work, the artist's unconscious and the viewer's potential for interpretation […] emphasising from the outset that the artist is not solely responsible for the work and that it is up to the viewer to bridge the gap with the world and play the game of interpretation, actively participating in the phenomenon of the transubstantiation of matter.[156]

Regarding his 1958 work Stacked Deck, almost contemporary to Duchamp's lecture, Higgins (2001) describes how he used audience reactions as cues for the development of the performance, removing the separation between audience and performance and thus creating a 'happening' situation. The idea of 'happening' is formalised by Kaprow, according to

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155 First drafted in 1952, the so-called "silent piece" stands out as an exceptionally concise model of Cagean chance and indeterminacy. 4'33" (or "four minutes and thirty-three seconds") is defined as a given time frame in which no intentional sounds are made. What is most significant about 4'33", of course, is the breath-taking void Cage creates, as if to structure the crucial gap that Duchamp had identified between creator and receiver, handing over some of the power of creation to the audience.
(Robinson, 2009, p.80)

156 On this subject, we suggest reading point 1.6(b) ‘The game of art’ in Miguel Leal’s doctoral thesis. (Page 64), where the author discusses ‘the delegation of a substantial part of the creative process to the viewer’.

With Higgins (1966), Allan Kaprow increasingly incorporated audience interaction into his collages until they became performances, and he formalised the idea of the 'Happening'. From this perspective, his happenings have no passive spectators, only participants. This participatory condition of the spectator allows them to experience the process of creating the work, stimulating their creativity and critical sense. The question of the positioning of the audience/spectator in relation to the work in the 'happening' is central and can be fundamental in the categorisation of intermedia.

It has already been mentioned how, in a happening, emptiness is eliminated and/or the space between performance, performer, creator and audience, or between stage and audience, is structured. But in order to affirm the possibility of the audience also being a medium, let us consider its position in relation to the media and technology. Parker-Starbuck (2011) considers that most media-based performances effectively position the audience apart from the media in what has become the predictable standard of television, computer screens, or video projections. Recalling that the integration of audience and technology is not new, Starbuck notes 'a shift towards an engagement that affirms the materiality of experiences with technology in the early days of the performing arts, reconnecting us physically as participants, while simultaneously questioning contemporary impulses towards an increasing virtual presence'. Thus, the opposite of placing the audience apart from the media is placing the audience as part of the media, that is, the audience is also a medium like any other that integrates the work. Still in this perspective, considering the performer as a means of materialising the work, the audience as a performer and, as such, also as a means of ma-

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157 "Allan Kaprow included audience relationships in his collages on an increasingly intense scale until his collages began to become performances, and he formalised the idea of the Happening."
(Higgins, 1966, p.107)

158 "What I am noticing here is a shift toward an engagement that foregrounds the materiality of earlier performance experimentations with technology and reconnects us physically as participants while also questioning contemporary impulses to be increasingly virtually present."
Parker-Starbuck (2011) (p.61-62)

The materialisation of the work refers to the thinking of Pauline Oliveros, who also radically eradicated the division between performers and audience.

When writing about the recent change in art's involvement with the local situation, Hawkins (2012) refers to artistic practices based on the 'local and social situation'[159] which, expanding the field of art, include the community as subject, material and audience. This almost sociological practice was also embodied in the work 'GreenRay', which, as a social and sensory laboratory, allows the body and its senses to explore new sensory experiences. The three works developed in this PhD, but in particular the work GreenRay, by integrating the viewer's body as a means of realising the work itself, fit perfectly into Hawkins' (2012) vision when he states that 'particularly important is the creation of space(s) (by the work) to which one can bring the body in its entirety, providing ... an understanding of the artistic experience apprehended not by an 'isolated intellectual act', but by the complex perception of the body as a whole'[160]. Higgins also seems to have considered this sociological framework when he writes: 'It is therefore our mission, as spectators, to establish a dialectic between what we think the artist does and what we choose, if we choose, to contribute to that process to the limit of our own personal enrichment and the re-experiencing of our identity in relation to what the artist does and in relation to our context and everyday world.' [161]

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159 "For, while undoubtedly monumental forms still exist, as well as those urban aesthetics created outside the circulation of theoretical art world discourses, it is site-based 'socially engaged' art practices, wherein artists take the social site, including its community, as subject, material and audience, that have been one of the important recent developments of art's expanding field."
Hawkins (2012) (p.56)

160 "Particularly important is the work's creation of 'space[s] to which you take your whole body, bringing . . . an understanding of the experience of art not as grasped by a ''solely intellectual act'', but by the complex perception of the body as a whole' (Hawkins, 2010a)."
Hawkins (2012) (p. 61)

161 "It is then incumbent upon us, who comprise the audience, to establish a dialectic between what the artist seems, to us, to be doing and what we choose, if anything, to contribute to that process to the ends of our own enrichment and of reexperiencing our own identities in relationship to what the artist is doing and in relationship to our own surrounding and daily worlds."
Higgins (1998) (p.83)

To support the idea of the spectator as a medium, and also of self-perception (of that same spectator) as a medium, Hawkins is paraphrased when he states that 'Art (...) allows us to think of the body as a tool through which research is done' (Hawkins 2012: 62). Leal (2009) considers that aesthetic and artistic experimentation depend on mechanical processes. These processes can be related to te-chné, with the use of machines and mechanisms in art, as well as to the similarity of some artistic systems to some mechanical systems. This author's research repeatedly refers to 'mechanisms of artistic practice' or even 'the mechanisms of thought and art'. In this way, artistic practice can also be considered as the operation of machines and mechanisms. Leal's thesis specifically addresses the 'mechanisms of indeterminacy in art'. It is also common in evolutionary psychology to refer to the 'mechanisms of (human) perception' and in constructive anatomy162 to refer to the 'human machine' or the 'mechanisms of the human body'. Thus, from a holistic perspective of the viewer that also includes their body, the viewer can be considered a machine, as a set of mechanisms; a mechanism in artistic operation.

In short, in addition to being an interpreter, the viewer can be considered a tool, a technology and a medium. The viewer is as important as any other medium necessary for the work to happen. This idea of equity or equivalence of the viewer to any other medium can easily be associated with the first phase of the post-media condition proposed by Weibel (2006), in which he affirms the equivalence of media, meaning their artistic equivalence and equal validity. This equivalence of media responds to a question that has certainly plagued many artists who have difficulty framing their work. For example, when

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162 See 'The Human Machine - The anatomical structure and mechanism of the human body' by George B. Bridgeman.

163 In this context, consider the viewer as the interpreter, thus contributing to the indeterminacy of the work of art.

164 It is important to note that for Weibel, this post-media condition comes after the effort to explore the specific idiosyncratic worlds of each medium.

are certain that no single medium prevails, they find it difficult to frame their work within the boundaries of sound art, video art or any other genre. In other words, artists today can frame their work within the intermedia field, where one medium is as important as any other, and no medium is dominant. Instead, all the different media influence and (in)determine each other. Weibel (2006) refers precisely to the mixing of media as the second phase of the post-media condition and states that the mixing of media has led to major innovations in each of these media and in art. Intermedia can also be considered as the equivalence of media, but Weibel's 'condition' should be supplemented by the compatibility of media. If intermedia is also integration, then it implies compatibility. Intermedia is therefore the compatibility of media. Jacqueline Henkel (1996), on the subject of interdisciplinarity, a term that has some etymological relation to the term intermedia, seems to make an apology for compatibility when she suggests that (interdisciplinary) projects work better when there is compatibility in the objectives of each discipline, stimulating new approaches to old problems[165].

JOHN CAGE

In fact, John Cage is an essential reference as a pioneer of Intermedia. Chase (1967) refers to Cage's considerations on the obsolescence of aesthetics, on the blurred boundary between art and life, on the analogy between music and the visual arts, and also, most importantly in the context of the experimental practice developed in the course of this research, on the value of the artistic process and experience. [166] Also from this perspective of valuing process and experience, Higgins (1966a) stated:

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165 "Whatever the interdisciplinary mode or aim, we would expect such projects to work best when the goals of each discipline are compatible enough to focus research but enough at odds to stimulate new approaches to old problems."
(Henkel et al., 1996)

166 "Art instead of being an object made by one person is a process set in motion by a group of people. Art's socialised. It isn't someone saying something, but people doing things, giving everyone (including those involved) the opportunity to have experiences they would not otherwise have had." Cage 1967

> So many artists were dissatisfied with this eternal and inflexible quality of their art that they began to wish their work were more like shoes, more ephemeral, more human, more able to admit the possibility of change. The fixed finished work began to be supplanted by the idea of the work as a process, which constantly becomes something else, experimental, allowing for more than one interpretation.[167] (Higgins, 1966a, p.1)

Still in the sense of sustaining and affirming indeterminacy as a characteristic of the intermedia, and considering John Cage one of the major influences on what Higgins would come to call intermedia, it is essential to refer in some detail to the way Cage explored and embraced indeterminacy in some of his works. Regarding the various versions of Cage's work 'Variations', Miller (2009) lists several determinations in Cage's notations that precisely determined the indeterminacy of the work, such as: 'for any type and number of instruments'; 'for any number of musicians and any means of sound production'; 'for any number of musicians, any sounds or combinations of sounds produced by any means, with or without other activities'. Lochhead (1994) even refers to Cage as a composer

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167 Translation by the author. Original:
'So many of the artists became unhappy about this eternal, unyielding quality in their art, and they began to wish their work were more like shoes, more temporary, more human, more able to admit of the possibility of change. The fixed-finished work began to be supplemented by the idea of a work as a process, constantly becoming something else, tentative, allowing more than one interpretation.' (Higgins, 1966a, p.1)

168 Miller considers that indeterminacy is also sensitive and reactive to the technological conditions in which the work is produced.

'Indeterminacy operates not only in terms of instrumentation and the determination of general parameters such as the duration of the performance, but also in relation to the means by which the work is created. In other words, indeterminacy is sensitive to changes in technological, historical or social conditions.' (Miller, 2009, p. 64)

Translation by the author from the original:
'Indeterminacy operates not only in realms such as instrumentation and determination of broad parameters such as performance length, but also with regard to the means by which a realisation is created. In other words, indeterminacy is responsive to changing technological, art-historical, or sociological conditions.' (Miller, 2009, p. 64)

which 'indeterminates'[169]. In this regard, Miller (2001) notes that Cage 'specifies processes but willingly accepts flexibility in realisation.'

Reinforcing the perspective of intermedia as a product of interactions between independent media, disciplines or systems, and considering that indeterminism can be synonymous with unpredictability, Ox (2001) maintains indeterminacy as a characteristic of intermedia: 'In many ways similar to the concept of complexity, intermedia implies an unpredictability of outcome based on sensitivity to initial conditions, and its final form can only be seen after going through the entire process
— transformation into a new form of intermedia.'[170] (Ox, 2001, p. 47)

One could speculate and play with the meaning and relationship between the words determination and indetermination, as in this context they appear almost paradoxical or absurd: the composer who determines indetermination or that which can be determined by indetermination. Miller (2003) is interested precisely in the second question: 'What is determined by indeterminate musical compositions?' In his argument, Miller states that the less specified the composition, the more indeterminate the result.[171] Cage's (in)determinations precisely enhanced the participation of performers in the process of creating the performance. This process of appropriation, according to Miller, reflects Cage's openness to whatever might happen. Miller also notes that Cage used indeterminacy and chance simultaneously in relation to

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169 In the context of the practical work developed in this PhD, materialised in three intermedia works, it is interesting to note precisely this idea of the author determining indeterminacy. Considering, for example, the work 'greenray', this is also configured for any number of spectators. Until the moment of presentation and 'creation' of the work, there is no predefined idea of how or how many spectators will act simultaneously or how long those spectators will remain acting.

170 Translation by the author from the original: *'Intermedia is the product of interactions between independent systems in time and space. In many ways similar to the concept of Complexity, intermedia entails an unpredictability of outcome based on a sensitive dependence upon the initial conditions, and the final form can only be seen after going through the entire process, the transformation into the new form of intermedia.'* (Ox, 2001, p. 47)

171 'The question may seem inherently absurd, since it is in the nature of such compositions to specify less and less, the greater the indeterminacy they exhibit.' (Miller, 2003, p. 18)

performance and notation of the composition. In the work 'variations', indeterminacy was also ensured by the unpredictability of the interactions of multiple systems simultaneously. The unpredictable result of these interactions gave the work one of its most important characteristics: irrepeatability. Cage's work questioned the conventions by which music is made. By systematically denying any relationship between sound and meaning, he freed music from any emotional or narrative expressiveness, forcing his audience to listen in a new way (Foster, 1985). Miller even considers 'variations IV' to be the pivotal work that paved the way for the development of 'total environments' that would be explored in 'variations V', an intermedia work created in collaboration with Merce Cunningham's dance company. The core of 'variations V' was already the real-time interaction between different media, with movement being the main means of activation. In this version of 'variations', the interaction between the different media suggested the generation of sound material from movement or video and the dynamic alteration of ambient light triggered by motion sensors. It is important to mention the works produced as part of this PhD, which function in exactly the same way, i.e. they materialise through the real-time interaction of the different media involved, and in all of them the physical movement of the spectators is the main and only means of activation. The choice of body movement as the main means of activating the works should be emphasised for two main reasons. Firstly, because body movement is an innate ability common to all human beings that recognises no language, gender or age barriers. Secondly, because the works resulting from this research do not use verbal language.

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172 James Pritchett provides a succinct distinction between indeterminacy and chance: while chance "refers to the use of some kind of random procedure in the act of composition," indeterminacy "refers to the ability of a piece to be performed in substantially different ways." Cage used chance in the preparation of the notations for Variations, but did not always instruct the performers to use chance in the execution of the notations.

Translation by the author from the original: 'James Pritchett provides a succinct distinction between indeterminacy and chance: while chance "refers to the use of some sort of random procedure in the act of composition", indeterminacy "refers to the ability of a piece to be performed substantially in different ways." Cage used chance operations in preparing the Variations scores, but did not always instruct performers to do so when realising them.' (Miller, 2009, p. 61)

nor figurative visual language [173], thus ensuring comprehensiveness, inclusion and accessibility to any human being regardless of their social or cultural status.

In the second performance of Cage's 'Variations VII', 'members of the audience left their seats and wandered among the equipment, increasing the sonic responses.174' (Miller, 2001, p. 560) In conclusion, Miller quotes Albert Reid (one of the dancers) when he states that 'for the audience it was an educational process: trying to make the audience see not only the dance but an entire world of sight and hearing'.

In the three works resulting from reflective practice in this PhD, the spectators participate in the event that is the work; more precisely, the spectators experience the event of the work. Without the participation of the spectators, the work does not even happen. Regarding the integration of the spectator into the work, it is concluded that, in addition to the importance of the experience provided to the spectator, it is essential to emphasise the equality of the spectator as a medium in relation to the other media that constitute the work. It is also considered that indeterminacy is enhanced by the inclusion of spectators in the work, and this task, although not an inalienable quality of art, is undoubtedly one of the most important of the works resulting from the research carried out in this PhD.

HOLISTIC AND HYBRID

In reflective practice, the holistic attribute presents itself as a possible common denominator. Although there are not many bibliographical references

173 Therefore, they cannot convey political, religious or social messages.

174 Translation by the author from the original 'At the second performance, audience members left their seats and wandered among equipment, further enhancing the sonic responses.' (Miller, 2001, p.560)

that use the term in association with intermedia, two references stand out as particularly significant and relevant.

Richard Lorber (1974), when discussing the appropriation of electronic technologies by artists, his contemporaries, in particular the appropriation of radio and television devices, presents video technology as a catalyst for integration into art forms that he calls 'holistic intermedia'. In the 21st century, Ken Friedman (2007) uses the term as an adjective to describe intermedia as a holistic or unified programme and to distinguish it from other concepts such as multimedia[175]. Tesuka (2011) also refers to the holistic unification present in one of the most recognised Japanese performing arts, 'Noh', which, according to Tesuka, inspired the famous intermedia collective Jikken Kobo.

The holistic nature of intermedia is also related to the equality between media, referred to in the previous section. In a comprehensive view of the intermedia phenomenon, it is important to understand intermedia as a whole and not as a plurality of media.

Another consensual and cross-cutting concept present in the theoretical approaches consulted in this research is the hybrid nature of intermedia. Higgins (1967), after some systematic development of the concept of intermedia, states that the term covers art forms that are 'conceptual hybrids' between two or more traditional media. Peter Frank (1982) states that the most radical aspect of artistic crossovers should be considered under the heading of intermedia, which he considers to be synonymous with all forms of hybrid art. McCombe (2006) presents intermedia as exactly synonymous with hybrid:

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175 Multimedia as multiplicity and simultaneity of media according to Friedman.

176 "Intermedia, in effect, denotes the wholly hybrid art forms that result from a seamless fusing of approaches and attitudes originating in the traditional arts. The elements in Wagner's operas -(…)- can be functionally isolated from one another without complete loss of coherence or even integrity;(...)" (Frank, 1982)

> These three works can be seen as hybrids or intermediaries where traditional artistic boundaries are blurred through the intertwining of music, text, video and performance (...) I believe that the practice of hybrid or intermedia arts provides a much more fruitful and exciting creative vehicle, both in terms of the individual composer/artist/creator and in terms of the development of a new work that articulates a variety of relationships between art forms and media.[177] (McCombe, 2006, pp. 299 & 309)

Kase (2009) refers to Higgins' position on artistic production in the post-war period, which tended towards hybrid artistic productions in which a variety of media were consciously mixed and interconnected. In the same text, he recalls Kirby's efforts to divide art history between Greenberg's theological purism
, defender of the specificity of media, and a 'fresh hybrid practice' that willingly challenged the boundaries between disciplines.[179] McLuhan (1994) refers to the hybrid encounter of two media as an event of enormous artistic, social and physical transformative potential, arguing that the 'encounter of two media', among other possibilities, can create new forms. 'The hybrid or confluence of two media is a moment of truth and revelation from which a new form is born' (p. 55)[180]. Kase (2009) writes that for McLuhan, hybrid projects worked

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177 "These three works can be regarded as hybrid or intermedia works in which traditional artform boundaries are blurred through the intertwining of music, text, video and performance. (…) I believe that a hybrid or intermedia arts practice provides a much more fruitful and exciting creative vehicle, both in terms of the individual composer/artist/creator and in terms of the development of new work that articulates a variety of relationships between artforms and media." (McCombe, 2006, p.299 & 309)

178 Kase, C. (2009). A CINEMA OF ANXIETY: AMERICAN EXPERIMENTAL FILM IN THE REALM OF ART (1965–75). (Doctoral dissertation). Retrieved from UNIVERSITY OF SOUTHERN CALIFORNIA. (etd-Kase-3268)

179 Ibid.

180 Translation by the author from the original: 'The hybrid or the meeting of two media is a moment of truth and revelation from which new form is born.' (McLuhan, 1994, p. 55)

as experiences capable of challenging social patterns of perception and thought.[181] Also emphasising the hybrid nature of intermedia, Friedman (2007) paraphrases Higgins' concept: 'the term intermedia refers to art forms drawn from the roots of various media, which are transformed into new hybrids' [182](p. 14).

Based on the literature review carried out in this research, there seems to be a consensus that intermedia generates something preliminary, something new. Ox (2001) confirms this approach: 'Intermedia is a combinatorial structure of syntactic elements originating from more than one medium but combined into one and thus transformed into [a] new [entity'183] (p. 47). Dorfles (1980) refers to the osmosis, symbiosis and confluence of different artistic languages as a trend that encourages contamination between languages and counteracts the 'stagnation' of [pure] languages. Dorfles relates intermedia to new technological and mechanical discoveries, considering it to be the creator of a new language and linguistic specificities constituted by the adoption of various codes. Like Higgins, Dorfles expresses difficulty in considering the existence of [artistic] categories, noting that the works of some artists (such as Dan Graham, Nam June Paik, Acconci, or Christo) cannot be classified as figurative arts, theatre, or any other category, as they are autonomous forms in themselves, despite their language deriving from the simultaneous presence of elements from different artistic languages. Dorfles also reflects on 'a transfer of the artist's field of action', seen by some as an impoverishment of a certain artistic expression and by others as

181 Kase, C. (2009). A CINEMA OF ANXIETY: AMERICAN EXPERIMENTAL FILM IN THE REALM OF ART (1965–75). (Doctoral dissertation). Retrieved from UNIVERSITY OF SOUTHERN CALIFORNIA. (etd-Kase-3268)

182 Author's translation from the original: 'the term intermedia referred to art forms that draw on the roots of several media, growing into new hybrids.' (Friedman, 2007, p. 14)

183 Translation by the author from the original: 'Intermedia is a combinatory structure of syntactical elements that come from more than one medium but are combined into one and are thereby transformed into a new entity.' (Ox, 2001, p. 47)

184 Cseres (2009) also seems to consider intermedia as the abolition of the purity of media when he describes the thinking of intermedia artist Adamciak as 'complete deconstruction of "pure" media and intermedialisation of creative activities'.

185 Furthermore, he states that the categories inherited from the past only partially corresponded to the reality of the present (the 1980s).

186 Transfer to the field of graphic arts, advertising, industrial design or theatre, performance or video.

Optimists such as Dorfles understand this as the enrichment and rebirth of global human creativity, as well as the possibility of 'autonomous individual creation'.

> Today, individuals can create their own private message through intermedia and, in this way, can regain expressive autonomy.[187] (Dorfles, 1980)

From Dorfles' thinking on intermedia, we should highlight the idea of intermedia as a rebirth of the global creativity of human beings. In 2013, Ascott (2013) affirmed and updated this concept, calling it interstitial creativity, recalling its fundamentals:

> Artists look everywhere, to any discipline, spiritual or scientific, immediate or distant in space or time, any technology, ancient or modern, to allow the free navigation of the mind and the open exploration of consciousness. (Ascott, 2013)

We do not recognise any meta-language or meta-system that places one discipline or worldview above all others. We seek inspiration and understanding in all directions: East and West; the path of the left hand and that of the right; working with reason and intuition, meaning and absurdity, subtly and sensitively.

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187 Translation by the author from the original: 'Today the individual can create his own, private message by means of intermedia and, in this way, he can reconquer expressive autonomy.' (Dorfles, 1980).

188 Translation by the author from the original: 'Artists will look anywhere, into any discipline, spiritual or scientific, immediate or distant in space or time, any technology, ancient or modern, to enable the untrammeled navigation of mind, and the open-ended exploration of consciousness.
We recognise no meta-language or meta-system that places one discipline or world-view automatically above all others. We look in all directions for inspiration and understanding: to the East as well as the West; the left hand path as well as the right; working with both reason and intuition, sense and nonsense, subtlety and sensibility.' (Ascott, 2013)

If Ascott refers to any practice that exists between, rather than within, the familiar boundaries of accepted genres and media, Ascott assumes boundaries as division.

Thus, seeking to summarise the perspectives discussed so far, it is considered that intermediation operates not only in the interstitial space, not only between limits and boundaries, but also, and mainly, on the threshold of the media. This issue of operation on the threshold will be discussed in the section 'Threshold Technology'.

EXPERIENCE

One of the main motivations of ORIP is to provide experience to both the artist and the participants.

> Men such as Robert Rauschenberg, Robert Morris, and Robert Whitman are more concerned with the personal responsibility of their audience than with the creation of objects to be 'owned', since ownership/property is seen as an irresponsible concept when global synergy is the obvious necessity. Therefore, it is clear that Duchamp's penetrating description of art as being "defined by context and completed by the viewer's response" anticipated the present symbiosis of the artist and the ecologist.[189] (Youngblood, 1970, p. 347)

189 Translation by the author from the original: *'Men like Robert Rauschenberg, Robert Morris, and Robert Whitman are concerned more with the personal responsibility of their audience than with creating objects to be "owned," since ownership is seen as an irresponsible concept when the obvious need is for global synergy. So we see that Duchamp's penetrating description of art as "defined by context and completed by the spectator's response" anticipated the present symbiosis of artist and* ecologist.*'* (Youngblood, 1970, p.347)

The concerns of Rauschenberg, Morris and Whitman seem to anticipate what is perhaps one of the greatest motivations of ORIPs: providing participants with experiences rather than creating objects that can be exchanged and owned. In ORIPs, as case studies, experience is the common element among the human beings who participate in them. For the artist, experience is an intention and is present in all phases of the materialisation of the work, from its conception to its realisation. For him, the experimental nature is constant because the intermedia work results precisely from the interrelation of experiences made with different material, technical, procedural, conceptual and human means, among others. The construction of the intermedia experience is influenced by the artist's experimental work, which provides participants with the experience of the work and, at the same time, allows them to complete it. In other words, participants experience the work as an audience but also actively participate in the action of making the work, in its finalisation. In turn, the artist can only experience the event of the work when it is experienced by the participants. In this sense, it can be said that there is a certain reciprocity of experience: the artist provides an experience to the participants, who, in turn, provide the experience to the artist. In other words, the participants experience the artist's experience, who experiences how his experience is experienced by the participants, who are also makers of the experience itself.

In an era of evident decline, due to the inhospitable growth of consumerist values in a self-destructive[190] capitalist society, in which the attraction and appreciation of owning objects (which quickly become obsolete and devalued) is almost universal, the production of experiences, even if ephemeral, counteracts this trend and reinforces with optimism the idea that 'we are what we do'[191], to the detriment of the idea that 'we are what we have' or 'we are what we possess'. In a way, ORIPs

190 It is called self-destructive because of the tendency of capitalist society to destroy existing values in order to 'sell' new ones.

191 Eduardo Galeano is quoted as saying, 'We are what we do, especially what we do to change what we are'.

reveal a political stance based on a philosophical principle: 'Doing rather than owning'.

In the literary universe, various types of experience are referred to, such as physical, mental, emotional, spiritual, religious, aesthetic, sexual, virtual, among many others. Arsenault and Bonenfant (2012) consider that 'experience can be divided into its various dimensions, such as technique (techne), ethics (ethos), aesthetics (aisthêtikos), etc.'[192] In turn, each of these dimensions can be further divided into multiple other dimensions. For example, Gallese and Di Dio (2012) consider that 'aesthetic experience is connoted as a stratified state where different dimensions can be distinguished'[193] associated with different forms of relationship with objects, such as 'mere observation, aesthetic attitude, aesthetic appreciation/evaluation and aesthetic judgement'. However, for Arsenault and Bonenenfant, 'these dimensions [technical, ethical and aesthetic] cannot be imagined separately from their effects and functions, combined as an inseparable whole that defines the meaning of life'[194].

It is not the aim of this research to dissect, separate and categorise the possible forms or dimensions of experience. Like intermedia, Experience is a continuum, a hybrid that cannot be defined because it is both ambiguous and comprehensive. The experience of an expert, the experience of seeing the ocean for the first time, or the experience of mixing materials that had not been mixed before, are at opposite ends of a multidimensional spectrum and have different semantic values. Experience is a constant in life. The members of the Austrian collective Monochrome (2005), creators of the manifesto Experience as Experience,

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192 Translation by the author from the original: *'experience can be divided between its many dimensions, such as the technical (techne), ethical (ethos), aesthetic (aisthêtikos),* etc.' (Arsenault and Bonenfant, 2012, p.1)

193 Translation by the author from the original: 'The term aesthetic experience connotes a multilayered state in which several dimensions can be distinguished […] mere observation, aesthetic attitude, aesthetic appraisal, and aesthetic judgement' (Gallese and Di Dio, 2012, p. 692)

194 Author's translation from the original: *'these dimensions cannot be envisioned separately from their combined effects and function as an inseparable whole that define the meaning of life.'* (Arsenault and Bonenfant, 2012, p.1)

ência'[195] consider that 'everything is related as experience. […]… everything must be experiential or presented as "experience".'[196]

Back in the 1960s, Carl Rogers wrote about the importance of experience in the emergence, formation and knowledge of ourselves as people:

> I have tried to give my picture of the characteristic attributes of the emerging person; a person more open to all the elements of his or her organic experience; a person who develops a trust in his or her own organism as an instrument of sensitive living; […] a person who is learning to live their life as a participant in an ongoing fluid process, in which the person constantly discovers new aspects of themselves in the flow of their experience.[198] (Rogers, 1961, p.124)

According to Varela (1991), who considered conceptualisation processes to be motivated by the structures of bodily experience, Hall (2010) argues that evolution is more related to our choices through experience than to improvements through adaptation. Experience is synonymous with knowledge and learning. According to the Portuguese language dictionary, experience is, among other things

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195 'Experience the experience' - http://www.monochrom.at/experiences/

196 Translation by the author from the original: *'everything is plugged as "experience". […]… everything has to be made "experiencable" or presented as an "experience". Yet there is not even a word for it in* German.' (Monochrome, 2005)

197 Carl Rogers affirms the supreme authority of experience: 'Experience is for me the supreme authority. The yardstick of validity is my own experience. No one else's ideas and none of my own ideas are as authoritative as my experience. It is to experience that I must always turn to discover an approximation of truth [...]' (Rogers, 1961, p. 23). Translation by the author from the original: *'Experience is, for me, the highest authority. The touchstone of validity is my own experience. No other person's ideas, and none of my ideas, are as authoritative as my experience.*
ritative as my experience. It is to experience that I must return again and again, to discover a closer approximation to truth[…]' (Rogers, 1961, p. 23).

198 Translation by the author from the original: *'I have tried to give my picture of the characteristic attributes of the person who emerges; a person who is more open to all of the elements of his organic experience; a person who is developing a trust in his own organism as an instrument of sensitive living; […] a person who is learning to live in his life as a participant in a fluid, ongoing process, in which he is continually discovering new aspects of himself in the flow of his experience.*' (Rogers, 1961k, p. 124)

synonyms, ‘knowledge acquired through practice’. Schinkel (2010), for whom experience is perception or imagination, brings experience closer to aesthetics by considering aesthetics as the experience of the senses. Experience also enhances knowledge. For Giannetti (n.d.), ‘the acquisition of knowledge, education and culture are dependent on individual life experiences’. Murdoch (2001) seems to emphasise the importance of context and group experience in learning when he states that ‘we learn by attending to contexts, vocabulary develops through close attention to objects, and we can only understand others if we somehow share their contexts’.

The three intermedia works resulting from the research carried out in this PhD can be considered as contexts for group experiences. In all the works, participants are confronted with a new environment/context, ready to experiment and for which they had no prior instruction. In other words, the works in question are also contexts for social interaction.

MIRROR NEURONS

The aim is thus to affirm these works as experiences that enhance knowledge and socialisation. In the last two decades of the 20th century, a group of neurophysiologists at the University of Parma considered the existence of

199 ‘On the one hand, art is concerned with aesthesis, with sense-experience.’ (Schinkel, 2010, p. 279)

200 Author's translation from the original: *‘We learn through attending to contexts, vocabulary develops through close attention to objects, and we can only understand others if we can to some extent share their contexts*.’ (Murdoch, 2001, p. 34)

201 Although the SoLu work is operated by one participant at a time, the fact that it is accessible to any member of the public means that it can also be considered a group experience.

202 Resulting from an intermediate process.

neurons that are activated in an individual when they observe another person performing an action or when the individual performs that same action themselves. This group of researchers called their discovery 'mirror neurons'[203] precisely because they are a kind of internal reflection of the actions of others. This discovery was quickly associated with language learning, motor skills, sociability and emotional processing.

In order to support the relationship between the theme of ‘mirror neurons’ and the works resulting from this PhD, as well as their power as knowledge-generating experiences, another consideration should be made: all the works developed are also spatial arrangements, they occupy space[204] and, as such, involve the movement and motor skills of the participants. Gallesse and Di Dio affirm the fundamental notion of the motor nature of experience and reinforce it: ‘It is through movement that the elements available in space can be connected, that objects can be extracted from their background and perceived, that representations and meaning can be formed and articulated’[205] (p. 688). Experts such as Fogassi and Ferrari[206] (2007) state that ‘mirror neurons are a class of neurons in the premotor cortex’ called ‘motor neurons’ and that the motor (neuronal) system itself is related to the evolution of language. In the case of the works resulting from the research in this PhD, in particular the works GreenRay and SynDyn, the movement of the participants is an integral component of the experience that is the intermedia work, therefore, there is reciprocal induction of activation of the participants' 'mirror mechanisms' (mirror neurons). According to Gallesse and Di

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203 For an introduction to the topic, we suggest consulting the following addresses: http://pt.wikipedia.org/wiki/Neurónio_espelho and https://en.wikipedia.org/wiki/

204 For more information on Space, see the 'Space' subsection in the 'GreenRay' section.

205 Adaptation by the author from the original: *‘A further interesting aspect of Hildebrand’s proposal concerns his notion of the fundamental motor nature of experience. It is through movement that the available elements in space can be connected, that objects can be carved out of their background and perceived, that representations and meaning can be formed and articulated.*’ (Gallesse and Di Dio, 2012, p.688)

206 These experts attempt *to* justify the *'hypothesis that various components of human language, including some aspects of phonology and syntax, may be embedded in the organisational properties of the motor system and that a deeper understanding of this system may help explain how language* evolved' (Fogassi and Ferrari, 2007).

Dio states that ‘the activation of the mirror mechanism for action is typically induced by the observation of ongoing actions, its relevance to the aesthetic experience during the contemplation of static works of art may be insignificant’[207] (p. 692). In their study, Gallesse and Di Dio, who identify the activation of ‘mirror mechanisms’ as ‘embodied resonance mechanisms’, suggest that these resonances also occur during the observation of fixed works of art such as paintings, sculptures, photographs, architectural works, etc. Hall (2010) calls this type of resonance ‘kinetic resonance’, caused essentially by gesture.

GESTURE

ORIPs are hybrid systems composed of human beings and non-human components. The non-human components are transformed from objects into subjects because they act on human participants, causing them to act and react. And these actions and reactions occur as gestures.

Hall (2010) calls these actions and reactions the participants' 'interactive gesture'. This suggests that the experience of the intermedia work depends more on what it elicits than on its appearance. In the particular case of the works resulting from the research carried out in this PhD, it is the essential gesture of the participants that is elicited. The bodily and facial gesture, whose system of performance and understanding is implemented in mirror neurons. Acharya and Shukla (2012) consider that it is from mirror neurons that human language evolved.

In fact, gestures and the imitation of gestures are, for many scholars, the key to learning language, empathy, and many other cultural advances.

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207 Translation by the author from the original: *‘Since the activation of the mirror mechanism for action is typically induced by the observation of ongoing actions, its relevance for the aesthetic experience while contemplating static artworks could be negligible.’* (Gallesse and Di Dio, 2012, p. 692)

Theories of neural mirrors as the foundation for the evolution of human language are just over a decade old. Johnson (2010), an advocate of embodied theory of mind, asserts that much of our perceptual knowledge originates from movement, both in our bodily movements and in our interactions with moving objects. McNeil (2006) states that gestures can be considered as agents of social interaction or as 'social stimuli'. Azar (2005) notes that the fundamental question in the agency of gestures in socialisation is how the brain moves from understanding actions as actions to understanding actions as symbols.

ORIPs, which intentionally do not use verbal language, stimulate what is perhaps the oldest and most primary form of human communication: gestures; the gestures of the body as a whole. As Hawkins (2012) states, an understanding of the experience of art is not only an intellectual act but also the complex perception of the body as a whole.

Supporting gesture as a means of socialisation, it can be concluded that ORIPs, in particular GreenRay and SynDyn, are social and socialising experiences. The gestures stimulated by the non-human components in each participant resonate with the other participants who can observe them. The gestures of each participant are therefore stimulated simultaneously by the human and non-human components of the system, in a kind of symbiosis. It should be clarified that in the specific context of the works in-

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208 'In 1998, Rizzolatti and neuroscientist Michael Arbib of the University of Southern California spearheaded the movement defending the theory that mirror neurons, for the act of grasping, may have evolved from the simple cells observed in monkeys into a sophisticated network enabling the symbolism and syntax of human language, with speech built on the foundations of manual gestures.' (Azar, 2005, p. 54) Author's translation from the original: *'Rizzolatti and University of Southern California neuroscientist Michael Arbib, PhD, spearheaded the movement in 1998 with a theory of how mirror neurons for grasping could have advanced from the simple cells seen in monkeys to a more sophisticated network allowing for the symbolism and syntax of human language with speech building on a scaffolding of manual gesture.*' (Azar, 2005, p. 54)

209 Scarinzi (2013) summarises the theory of the embodied mind as a rejection of the separation of mind and body, which sees meaning, reason and imagination as embodied and links reason to emotion. In other words, according to Scarinzi, experience and cognition are mediated bodily and depend on the sensory-motor capacities of individuals immersed in a biological, psychological and cultural context that interacts with the environment in a relationship of co-determination. (Although the theory of embodied mind is completely relevant in the context of the present investigation, it is concluded that that this is not a relationship of co-determination but rather one of co-indetermination.)

In this case, the gesture, rather than being a result of the work, is also one of the means of the work. The participants' gesture is a means of the work because it acts at the entrance to the system that integrates it and, at the same time, it is a result of the work because the work provokes this gesture.

ENACTION AND PRESENTATION

Just like interaction, which is both a means and a result of intermedia work. Hall (2010) writes, '[The] exchange between observer and an autopoietic work should be considered a relationship of equality. […] In other words, the exchange is both an instrument and a result.'[210] It is important to retain this idea, that exchange, interaction and gesture are both means and results of the work. At times, Hall seems hesitant when he still assumes a separation: the human who relates to the work, the human who relates to the non-human. Hall states that 'autopoietic aesthetics211 arises from human interaction with an artistic system that is self-propelled by its own sculpture'. This point of view presupposes the human being as an entity outside the artistic system. On the contrary, in the present investigation, the aim is to affirm the human being (artist and participants) as part of the system itself, so that interaction does not occur, as Hall states, with the system, but rather within the system itself as its integral component.

Popper (2007) also seems to hold the 'artist' responsible for the relationship between biological humans and mechanical non-humans:

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210 Translation by the author from the original: '*[The] exchange between an observer and an autopoietic work of art should be considered an equal relationship. […] In other words, the exchange is both an instrument and an outcome.*' (Hall, 2010)

211 See section 'Serendipity, Indeterminacy and Autopoietic Intermedia'.

> The only true task for an artist is therefore to make humans aware of the physical forces that surround them. This awareness can only be achieved by liberating these forces through an aesthetic experience. This experience must be active, involving the combination of the human senses.[212] (Popper, 2007)

From our point of view, and as a result of a long process of reflection and research, we understand that both human and non-human components constitute the work itself; that is, humans do not merely interact with the work, but humans and interaction are also the conceptual and biochemical experience of the work itself. It is a matter of 'the contraction in a single moment of the experience of making and contemplating the work' (Walley, 2011). Hall also affirms the possibility of rejecting observer-work distinctions:

> Possibly, [...], we have reached a historical moment that rejects the distinctions between the life of the observer and the life of the work [of art]. The life of the mechanical and the life of the biological may appear to be the same in their functioning, particularly when viewed from within the dynamics of autopoiesis.[213] (Hall, 2010)

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212 Translation by the author from the original: *'The only true task for an artist is therefore to make humans conscious of the physical forces that surround them. This consciousness can only be achieved by liberating these forces through an aesthetic experience. This experience must be an active one, involving a combination of human senses.*' (Popper, 2007, p. 32)

213 Translation by the author from the original: *'Perhaps, just as importantly, we may have come to a historic moment that rejects distinctions between the life of the viewer and the life of the artwork. The life of the mechanical and life of the biological can appear the same in their functioning, particularly when viewed from within the dynamics of autopoiesis. Biological and mechanical life has already transformed in a variety of ways in society.*' (Hall, 2010, p. 2)

Hall considers this collapse between object and observer as the ‘modelling of an event’, ‘the transformative negotiation of the interactive moment embodied simultaneously in machine and biology’.[214] This radical removal of the subject-object distinction, which Hall calls 'endo-aesthetics', focuses solely on the action or activity of the event, affirming the 'similarity between thought and action in the interactive moment'. This supports the idea that the experience of the intermedia work and the phenomenology of interactive aesthetics depend greatly on ‘what the work of art stimulates, in terms of the embodied patterns of action and reaction, between the functioning of the observer and the work’. And what ORIPs stimulate are mainly [enactive] experiences and knowledge. Halsall (2008) considered intermedia as a practice that attempted to make art without producing unique objects, and in fact the works resulting from the research in this doctoral thesis update and reinforce this consideration because they do not result in objects but rather in events, enactive happenings.

According to Choudhury and Slaby (2011), enactment refers to the dynamic integration of perception, cognition and knowledge in action, denoting the unification of sensory-motor activity. For these authors, ‘enactive approaches are anti-representationalist’ because they consider that there is no ‘spectator-like view of an “external” reality’, but rather ‘an interactive process in which an intimate mutualism is established between organism and environment (in other words, “enaction”)’. Moyal-Sharrock (2013), who considers Wittgenstein a pioneer of ‘enactivism’, emphasises the relevance of his [thinking216] and states that for this philosopher ‘it is action and not propositions that are the basis of all our speaking and thinking’.

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214 Translation by the author from the original: *‘In the collapse between the object and the observer, on this new modelling of an event, there is a transformative negotiation of the interactive moment embodied in both machine and biology.*’ (Hall, 2010, p. 10)

215 Higgins (1968) already referred to the creation of experiences as stimuli for participants: ‘Fluxus created experiences that serve as stimuli for participants and spectators, resulting in more meaning in their life and works’.

216 Moyal-Sharrock mentions the importance, influence and relevance of Wittgenstein's thinking in the most modern trends in the fields of philosophy of mind, epistemology, psychology and cognitive sciences.

Bruner (1974) introduced the term enactment in 1966, referring to the first way in which human beings preserve experiences in a model through action, that is, as the first form of representation. Bruner developed a conical scheme to illustrate 'the usual course of intellectual development' that moves from the enactive mode (base of the cone), through the iconic mode (middle of the cone), to the symbolic mode of representing ideas (top of the cone). This scheme supports the idea that intellectual development, from the base of the cone to its top, is a path towards abstraction. Later, Varela (1991) and his associates, who considered the relationship between experience and cognition to be processual, criticised the representationalist idea of the mind as a 'mirror of nature', proposing 'the term enactive to emphasise the growing conviction that cognition is not a representation of a world pre-given by a pre-given mind-given world, but rather the 'enactment' of a world and a mind based on a history of the variety of actions that a being produces in the world'[218] (p. 9). In his approach to enactment, Zarrilli (2011) considers experience as a process of engagement with the dynamic possibilities of a particular form or structure as it happens. Thus, according to Pasquinelli and Stewart (2007), 'enactive knowledge is a form of knowledge characterised by the fact that it is not propositional ("knowing that"), but rather procedural ("knowing how"). Therefore, enactive knowledge is primarily 'knowledge for action'; conversely, action is always necessary in order to acquire enactive knowledge'[219]. At the enactive level, experience is a non-verbal form of knowledge or, considering Bruner's conical scheme, a pre-verbal form of co-

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217 The cone diagram was introduced by Edgar Dale (1946) in his book on audiovisual methods for teaching. The Cone of Experience is a visual device summarising Dale's classification system for the various types of mediated learning experiences. The principle of organisation of the Cone was a progression from the most concrete experiences (at the base of the cone) to the most abstract (at the top) (Molenda, 2003) (Author's translation). In the third edition of his book, Dale superimposed Jerome Bruner's classification system for modes of learning
(inactive, iconic and symbolic).

218 Translation by the author from the original: *'We propose as a name the term enactive to emphasise the growing conviction that cognition is not the representation of a pre-given world by a pre-given mind but is rather the enactment of a world and a mind on the basis of a history of the variety of actions that a being in the world performs'* (Varela, 1991, p.9).

219 Translation by the author from the original: *'Enactive knowledge is a form of knowledge which is characterised by the fact that it is not propositional ("knowing that"), but rather procedural ("knowing how"). Thus, enactive knowledge is primarily "knowledge for action"; conversely, action is always necessary in order to acquire enactive knowledge.*' (Pasquinelli and Stewart, 2007)

knowledge. Stice (2009) states that Dale's cone, to which Bruner's classification system was superimposed, was ordered by increasing levels of learning efficiency. Ryan (2005) considers that preverbal memories cannot be retrieved verbally or (in fact) consciously known, but can be implicitly understood from behaviour, and therefore identifies this type of memory as enactive or implicit[220].

> On enacting knowledge, the members of the Enactivenetwork project (n.d.) write: Enacting knowledge is not simply multisensorily mediated knowledge, but rather knowledge stored in the form of motor responses and acquired through the act of 'doing'. […] This type of knowledge transmission can be considered the most direct, in the sense that it is natural and intuitive, as it is based on experience and perceptual responses to motor acts[221].

The works resulting from the research in this PhD, which do not convey any verbal message, occur primarily and almost exclusively at the enactive level, thus becoming ineffable experiences. Although these works are ephemeral experiences, considering Bruner's hierarchy, which suggests that the memory of enactive knowledge is more efficient than that of symbolic knowledge, one can speculate that the experience of these works is potentially more memorable.

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220 Paraphrase of the author from the original: *'Memories from a pre-verbal level cannot be retrieved verbally or indeed known consciously in the normal sense, but they can be understood implicitly from behaviours. This is called "enactive" or "implicit" memory,* […]' (Ryan, 2005, p.144)

221 Translation by the author from the original: 'Enactive knowledge is not simply multisensory mediated knowledge, but knowledge stored in the form of motor responses and acquired by the act of "doing".[…]This type of knowledge transmission can be considered the most direct, in the sense that it is natural and intuitive, since it is based on experience and on perceptual responses to motor acts.' (enactivenetwork.org, n.d.)

From this perspective, and based on the arguments presented, the works in question can also be considered as enactive interfaces. At present, when the traditional use of computers involves interaction based predominantly on symbolic and/or iconic (disembodied) knowledge rather than on enactive (embodied) knowledge, the works resulting from this research counter this trend by providing an experience that does not require any kind of literacy or alphabetisation. According to members of the Enactivenetwork community, 'enactive interfaces can be considered a new step in the development of human-computer interaction because they are characterised by a loop [closed circuit] between the user's natural gestures (efferent component of the system) and the activated perceptual modes (afferent component)'[222]. Bennett and O'Modhrain (2007) define enactive interfaces as interfaces that allow the expression and transmission of enactive knowledge. Considering the manipulation of enactive knowledge mediated by enactive interfaces as a ‘particularly direct means’ of communication between humans and computers, these authors affirm the convenience and opportunity of enactive interfaces because they allow participants to use their prior knowledge of interaction with the world. In a review of Gary Shapiro's work 'Archaeologies of Vision: Foucault and Nietzsche on Seeing and Saying', Ziarek (2007) seems to make an apology for enactment as a characteristic of contemporary art when he writes:

> 'I am choosing this term "enactive" deliberately in order to emphasise two points. First, the thinking that is at stake here, the thinking exemplified in modern and contemporary art, is not reflective, representational, or imitative, but instead constitutes a kind of act. Second, this thinking is not

222 Translation by the author from the original: ‘Enactive Interfaces can be considered a new step in the development of human-computer interaction because they are characterised by a closed loop between the natural gestures of the user (efferent component of the system) and the perceptual modalities activated (afferent component).’ (enactivenetwork, n.d.)

> ‘inactive’ with the prefix ‘in’, even though it is often thought to be so. As homophones, [... the] distinction between enactive and inactive only becomes visible in writing [... which] may signify the emergence of a completely different visibility, the parameters of which modernity has been working on since at least Nietzsche.’[223] (Ziarek, 2007)

In the case of ORIPs, enactment is another element of the intermediary system experience that gives it its presentative character. Macedo[224] (2010) relates the presentative character as opposed to the representative, associating the former with space-time contraction: 'the participation of the spectator, including them in the system, causes a contraction of the space-time distances between spectator, work of art and creator [... The] aesthetic manifestation of the work takes place in real time at the moment it is experienced [...]'.

> On presentative art, Virilio (2005) states: [It] does not seek to last. It does not negotiate with the past, since we have broken with it, nor with the future. […] These are arts in the present tense, arts in real time. We are returning to ‘live’. It is living art, and the only thing that matters is its instantaneity […][225](p. 46).

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223 Translation by the author from the original: *‘I am choosing this term “enactive” deliberately in order to emphasise two points. First, the thinking at issue here, thinking exemplified in modernist and contemporary art, is not reflective, representational, or imitative, but constitutes, instead, a kind of act. Second, this thinking is not “inactive” with the prefix “in”, even though it is often mistakenly taken to be so. As homophones, [… t]he distinction between enactive and inactive indeed becomes visible only in writing, and [… that] may signal an emergence of an altogether different visibility, one on whose parameters modernity has been labouring at least since Nietzsche.*’ (Ziarek, 2007)

224 Macedo notes that Virilio (2005) considers ‘spatio-temporal contraction, like the pollution of spatial and temporal distances, to also threaten the contemporary artistic event, which, ‘polluted’, only presents itself’.

225 Translation by the author from the original: *‘It doesn’t deal with the past, since we broke with it, nor the future. […] These are arts in the present tense, arts in real time. We’re coming back to the “live.” It’s live art, and the only thing that counts is its instantaneity* […]’ (Virilio, 2005, p.46)

The aforementioned consideration by Bennett and O'Modhrain of enactment as a direct medium seems to corroborate the approximation of presentation to immediacy. Unlike representation, which is limited to the level of abstraction (less direct and less immediate) and generally refers to something that is absent, at least temporarily. As early as the 1950s, Abrams (1974) considered the apprehension of works of art to be contemplative, disinterested, free from will and desire, and therefore opposed to practical and cognitive concerns. In a way, Abrams already suggested some immediacy when he wrote that the function of presentational art was to be a 'terminal good' and not a 'persuasion to beliefs'. Terminal refers to a peak, which in turn refers to an instant.

Returning to the question with which the 'Experience' section began, the responsibility of the audience is now associated with the responsibility of the artist. Popper (2007) addresses the question of the responsibility of the artist, meta-creator, producer and audience participation, starting from the individual-social opposition in which he questions whether the artist 'creates for the audience or simply follows his own creative impulse'. In the context of the works resulting from the research in this PhD, we disagree with this opposition because we consider that the responsibility of the researcher, artist, meta-creator, producer, is both to create for the audience and to follow their creative impulse, but more importantly, their responsibility is to create with the audience. Therefore, in the works referred to, responsibility is shared among all human agents. If for the participants there is the aforementioned contraction between the experience of making the work and the experience of contemplating it, for the researcher-artist there is maximum dispersion, since their experience as the maker of the work is not simultaneous with the experience of the participant.

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226 Virilio (2006) states that what abstraction (abstract art) once attempted is now being achieved: the end of representative art and its replacement by presentative art.

227 At the end of the 20th century, Higgins (1998), who still considered the viewer as a receiver rather than a participant, suggested that the viewer's participation completes the erotic component in the intermedia process: '[...] the receiver sympathises [with the work] and experiences its principles [...] physically, intellectually and intuitively; accepting the experience, merges the work with what they know and the projected horizon with their own, and the fusion completes the erotic in the process.' Translation by the author from the original: '[...] *the receiver empathises with it* [work] *and experiences its principles both physically, intellectually and intuitively; one accepts the experience, one fuses the work with what one knows and the projected horizon with one's own, and the fusion fulfils the erotic in the process*.' (Higgins, 1968, p.14)

their experience of contemplating it. This happens because, for the artist, the experience of the work is only complete with and through the experience of the participants. In other words, the artist only knows their work when it is presented to and by the participants. And at that moment, making the work happen no longer depends on the 'researcher-artist', who can only know the result of their experience at the precise moment when that result occurs.

In short, the responsibility of the author of ORIP is to counteract the tendency to 'reject the human body or its virtualisation'[228] (Armitage, 2002) by providing an immediate, corporeal experience, given that our existence is present. As Maturana (2013) stated, 'The future does not exist. In other words, the future is what we think may happen. Because we exist in the present. In a changing, continuous present... so that in reality our life occurs in the present.'

In this section, we could also discuss the experience of the hybrid researcher/artist/author/designer/producer and how this experience shapes knowledge and mastery, forming this very hybrid. Given that this experience is related to one of the central themes of this research — reflective practice as a guide to research itself, and reflective practice as a form of thought — this theme will be discussed in greater depth in the next chapter.

228 Adapted and translated by the author from the original: *'Rejection of the human body or its virtualisation, declares Virilio, are the only alternatives presented to the art lover by the multimedia academy led by body artists such as Orlan and Stelarc.'* (Armitage, 2002, p.22)

PRACTICE

Refsum (2002) considers that artists deal mainly with what happens before the execution of the works, that is, the processes that lead to the finished works. In the context of the works resulting from the research process developed in this PhD, it is confirmed that the researcher in intermedia deals with what happens before the presentation of the works. Considering that the exploratory dynamics that precede the presentation of the works is artistic practice, the next section of this text begins with a summary of the recognition that artistic practice receives as a credible proto-collaboration for research in academia in Portugal.

The aim is to substantiate and justify the type of knowledge achieved through artistic practice, and how this knowledge can be disseminated in an academic and cultural context. Firstly, it is important to clarify that the works produced in this research project are the result of a continuous process of research that is grounded, based on, and guided by reflective practice. Secondly, it is considered that the greatest impact of the transformative act of research on the artist's knowledge stems from the complexity of the reflective practical experience.

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229 In the case of the works developed in this PhD, the researcher was simultaneously Author, Designer, Artist, Theorist, Producer, Architect, Sculptor, Engineer, among others.

These works resulted from the exploration of knowledge in the areas of physics, electronics, computing, design, music, sculpture, sport, art, among others. In all these areas, technical mediation is mandatory, which highlights the fundamental role of technology in the production of knowledge.

The discussion developed in the following sections of this thesis, as a means of dissemination in the academic community, aims to share a verbal theoretical argument about knowledge, formalised essentially non-verbally: acquired knowledge, such as traditional practices; and 'knowledge in action', such as competence and skill.

PRACTICE AS RESEARCH IN ACADEMIA IN PORTUGAL

During the first decade of the 21st century, there still seems to be no consensus on the recognition of artistic practice as a credible research process. Sullivan (2006), who considers that artistic practice, as a creative and critical form, can be conceptualised as research, affirms the misconception of favouring and prioritising scientific rationalism as the only valid form of [academic] research philosophy. According to Sullivan, in addition to critics within the academic community, the political arena also contributes to this favouritism by determining restrictive research policies that are largely unrelated to some current academic practices.

In the specific case of Portugal, a report was drawn up which concluded that, in 2009, the academic offering in the country was ‘mainly based on historical, theoretical and critical pedagogies with little, if any,

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230 *‘Within an environment of standardisation and testing, a misguided tendency that favours scientific rationalism as the only valid form of educational research philosophy is prevalent.’* (Sullivan, 2006, p. 22)

evidence of learning through practice-based exercises'231 (Blumenreich, et al., 2009). The same report also states that 'as in other nations, the conventions and habits that dominate Portuguese universities may still consider methods based on the practice of performing and creative arts as inappropriate or unsuitable for advanced academic research'[232] (Blumenreich, et al., 2009). In other words, according to this report, 'in most universities, PhD methodologies are largely based on textual sources and scientific paradigms'. Furthermore, although 'there are no formal restrictions', PhD degrees are obtained on the basis of a written thesis. It was interesting to note the 'rapid response', almost immediate, from the Portuguese state, which on 14 September 2009 published Decree-Law No. 230/2009, legislating that:

> […The] cycle of studies leading to a doctoral degree may, under the conditions laid down in the regulations of each higher education institution, be integrated […][n]the field of arts, by a work or set of works or achievements of an innovative nature, accompanied by a written justification that explains the process of conception and elaboration, the capacity for research, and its place in the evolution of knowledge in the field in which it is inserted. (MCTES, 2009)

231 Author's translation from the original: *'The Universities offer the three cycles of the Bologna framework, i.e. BA, MA, PhD. These are mainly based on historical, theoretical and critical pedagogies with little, if any, evidence of learning by doing through practice-based assignments*.' (Blu-menreich, et al., 2009, p.9).

232 Translation by the author from the original: *'As with other nations, the conventions and habits that dominate Portuguese universities may still regard practice-based methods in the creative and performing arts as inappropriate or unsuitable for advanced academic* research' (Blumenreich, et al., 2009, p. 23).

The aforementioned decree stipulates that the work, set of works or achievements may be integrated into the process of obtaining a PhD, but the Blumenreich report (et al., 2009) on evaluation states that 'universities may not yet have sufficient knowledge of practice-based methods to have the "appropriate advice" that will identify the appropriate assessment committee for a practice-based PhD.'233 Furthermore, according to the decree, the cycle of studies leading to a PhD, although it may include works or achievements, must be based on a thesis.identify the appropriate assessment committee for a practice-based PhD'.[233] Furthermore, according to the decree, the cycle of studies leading to a doctoral degree, despite integrating works or achievements, does not dispense with written justification, i.e. literature, which should not be confused with theoretical justification. This means that, legally, artistic practice as an act of research and its results, work or works of art, have no value per se in academia. The work of art resulting from research through artistic practice still legally requires a literary complement, written justification, to be considered research in the academic context. This criterion seems to maintain a certain hierarchy of the functional value of written verbal language in relation to any other language or languages that may be used in artistic construction. Theory is often confused with literature, literature is often considered the best vehicle and support for theory, and theory conveyed through literature is often considered more erudite.

The works produced in this PhD are the result of a process in which thought and reflection were inseparable from action, that is, theory was inseparable from practice. However, traditionally, there has been a dispute and a hierarchy of knowledge, particularly between theory and practice. The following section of this text presents the reasons behind the continuing dispute and hierarchy of knowledge.

233 Translation by the author from the original *'In this latter respect universities may not yet have sufficient knowledge of practice-based methods to have the 'competent council' that will identify the appropriate assessment committee for a practice-based* PhD' (Blumenreich et al., 2009, p.25).

Techné and *Episthémé* - from polarisation to hierarchisation.

Following the research carried out, there is no intention to dissociate practice from theory. On the contrary, just like intermedia, with its hybridity and continuity, the knowledge acquired and generated by this research (intermedia practice) is also hybrid, that is, the intention is to affirm precisely the unity (union), breadth and reciprocity of theory and practice.

Regarding the hierarchy of knowledge, Weibel (2001) states that '[the] new era, the new world is dependent on theory. However, an interesting point is that the only field in which people do not accept dependence on theory is art'[234] (p. 273). Wilson (2003) recalled that for Roy Ascott, art 'functions both as theory and practice, and simultaneously as neither, as an entity in itself drawn from the theory and practice of other disciplines'[235] (p. 484).

The dualism between theory and practice seems to be based on the evident and profound separation between *Episthémé* and *Techné* as modes of knowledge. According to Heidegger (1977), 'from the earliest times until Plato, the word *techné* is related to *episthémé*. Both words are names for knowledge in the broadest sense. They mean to be completely at ease in anything, to understand and be an expert in that thing' (p.13). In other words, until Plato there was a convergence in the meaning of the two terms, since, for this philosopher, the two terms were almost interchangeable. Also according to Heidegger, *'techné* is the name not only for the activities and skills of the craftsman, but also for the arts'.

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234 Translation by the author from the original: *'The new era, the new world is theory dependent. However, an interesting point is: the only field in which people do not accept dependence on theory is art.*' (Weibel, 2011, p.273)

235 Translation by the author from the original: 'Art for Ascott functions as both theory and practice, and simultaneously as neither, as an entity unto itself drawing on the theory and practice of other disciplines.' (Wilson, 2004, p. 484)

of the mind and the fine arts.'[236] Above all, Plato did not oppose the terms *episthémé* and *techné*, associating them, respectively, with knowing and doing. However, his writings determined that *episthémé,* as primary knowledge*,* would be superior to *techné,* whether (*techné*) involved skills for acquiring knowledge or the creation of objects or images.

The Aristotelian classification of 'thought', according to Hazelrigg (1988), reproduces the separation (*episthémé/techné*) but with some variations: *theôria* or disinterested knowledge; *praktiké* or knowledge of human action; *poietike* or knowledge of doing things, which is divided into *téchne* or manual, functional arts and *poetics* or fine arts. This dissociation of *episthémé/techné* would motivate the birth of the contradiction between idealism and realism, which, according to Kaplan (2008), are nothing more than strategies[237] for dealing with the inconsistencies, intuitions and assumptions of common sense.

This taxonomy is also responsible for the differentiation and hierarchisation of forms of knowledge; certainly for the dichotomies that still exist for many human beings between thinking and doing; it undoubtedly gave rise to the separation of epistemology and technology, theory and practice, science and art. For Hazelrigg, the consequences of this taxonomy are an authentic 'winter': '[…] our history of philosophy (e.g. Russell) tells us almost uniformly of the long hibernation after Aristotle, of almost two millennia […]'[238] (p. 33). At the same time, this hierarchisation of forms of knowledge is associated with severe social stratification. Wiebel (2006) recalls this distinction and its relationship with freedom and stratification.

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236 Author's translation from the original: *'Techné is the name not only for the activities and skills of the craftsman, but also for the arts of the mind and the fine arts'* (Heidegger, 1977, p.13).

237 Paraphrase of the author from the original: *'[…]realism and idealism represent different strategies for navigating the inconsistent commitments of common sense, the intuitions and presuppositions from which our philosophical view grow.'* (Kaplan, 2008, p.86)

238 Translation by the author from the original: *'And our history of philosophy (e.g., Russell's) tells us almost uniformly of the long hibernaculum after Aristotle, nearly two millennia long […]'* (Hazelrigg, 1988, p.33)

social stratification: *episthémé* — cognition and knowledge comprising rhetoric, arithmetic, geometry, astronomy, dialectic, grammar and music theory — reserved for the community of free citizens; and *techné* — technical skills and crafts — for non-free citizens, wage labourers and artisans (*technites* or *banausos*). Weibel emphasises Aristotle's undisguised contempt for the status of craftsmen, whom he saw as bordering on slavery. In other words, 'Aristotle produced the commensurability of the aesthetic and social orders. [...] The sciences (*episthémé*), ranging from arithmetic to rhetoric, were for free citizens. The arts (*techné*), ranging from architecture and agriculture to painting and sculpture, were for unfree men' (Weibel, 2006). The Romans would replace this division between *episthémé* and *techné* with the distinction *between artes liberales* and *artes mechanicae*, maintaining the commensurability of the aesthetic and social orders and reinforcing the hierarchy of the arts and artistic skills. According to Weibel, what we know today as sciences were the *liberal arts* of the past, and the arts as we understand them today remained within the horizons of *téchne*.

During the Renaissance, perhaps in a struggle for the emancipation of the so-called greater arts, the *paragone*[240] took place, a concept so robust that it has persisted to the present day (Preimesberger, 2011). Modern bourgeois culture allows architecture, painting and sculpture to 'ascend' to the status of *liberal arts.* Weibel ends his essay on the 'post-media condition' by considering 'that the dispute over the arts has ended, but the dispute has returned to its origins, to the relationships between theory, science and practice, art.'

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239 Translation by the author from the original: *'Hence Aristotle produced a commensurability of the aesthetic and social order. [...] The sciences (episteme) ranging from arithmetic to rhetoric were for free citizens. The arts (techné) ranging from architecture and agriculture to painting and sculpture were for the unliberated.*' (Weibel, 2006)

240 Italian Renaissance term referring to a dispute over the superiority of painting over sculpture. For historical information on this topic, we suggest consulting the work *'Paragons and Paragone: Van Eyck, Raphael, Michelangelo, Caravaggio, and Bernini',* by Rudolf Preimesberger.

241 Translation by the author from the original: *'The contest of the arts is over, but the contest returns to its origins, to the relations between theory, science and practice, art.*'

In practice, the contest of the arts may be over, but the hierarchy may be irreversible. Consider the Portuguese academic landscape, where the teaching of art history still induces the hierarchy of architecture, painting, sculpture, followed by the so-called minor arts. The average entry requirements for each of these courses in public higher education, as well as the ‘prestige’ and social status of each of these professions, are still directly proportional to this hierarchy.

In order to contribute to ending this dispute and reaffirming the absolute equality of the media in the process of intermediate transformation, the next section discusses the possibility of unifying different areas of knowledge and the fundamental role that technology plays in this process of hybridisation.

THRESHOLD TECHNOLOGY

If Weibel considers that there is a return to origins in the dispute between theory and practice or science and art, Flusser (1999) seems to suggest that this dispute has been more permanent throughout history. Flusser states and argues that the terms *design*, *machine*, *technology*, *ars* and *art* are closely related to each other and that each of these terms is unimaginable without the others. According to this philosopher, this connection was denied for several centuries, opening an 'irreversible' cultural gap between a quantifiable aspect (science) and a value-based aspect (aesthetics). This split justifies Biglan's (1973) classification model, in which a spectrum of hardness is associated with different areas of knowledge. Flusser considers that design precisely bridges the 'hard' (science) and 'soft' (art and humanities) extremes of this spectrum, making them equivalent and thus enabling a new culture.

Anything can be a medium. Theory and practice, science and art can all be considered media. This consideration allows us to suggest a relationship between the 'new culture' referred to by Flusser and the post-media condition theorised by Weibel, that is, the equivalence between media, between hard and soft disciplines, between forms of knowledge.

Flusser uses etymology to speculate on the equivalence between art and technology:

> The Greek term *techne* means 'art' and is related to *tekton*, a 'carpenter'. […] The Latin equivalent of the Greek *techne* is *ars*, […] *ars* means something like 'agility' or the 'ability to transform something for one's own benefit, […] In German, an artist is clearly someone who is 'able to do something', the German word for art, *Kunst*, being the noun form of *konnen*, 'to be able to' or 'to manage' [...] (Flusser, 1999, pp. 17-18)

Flusser also speculates on the relationship between the term art and the terms artifice, artificial and artillery, associating this relationship with illusion, cunning, deception and trickery. According to this philosopher, the idea of deception is also associated with technology and mechanics: 'The Greek word *mechos* means a device designed to deceive — i.e. a trap […] Consequently, a machine is a device made to deceive; a wing, for example, defies gravity, and mechanics is the trick to deceiving heavy bodies.'[242] If what we know today as science was once *artes liberales*, one could base speculation on the total artificiality and illusion of the premises of scientific and rational knowledge. Maturana (2013) argues: '[a]ll rational systems are based

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242 Translation by the author from the original *'The Greek mechos means a device designed to deceive - i.e. a trap [...] Consequently, a machine is a device designed to deceive; a lever for example, cheats gravity, and 'mechanics' is the trick of fooling hey bodies.'* (Flusser, 1999, p. 17)

on premises that are not rational. Fundamental premises accepted a priori. The mathematical formalism on which it is based? On certain coherences that I accept as primary elements for my logical construction.'[243] In the same speech, Maturana states that rationality is an instrument we use to see more, in a space of coherences, or to convince others to accept what we say. In this sense, the tools, instruments, techniques, technologies and theories resulting from 'rational' thought and action can be considered artificial means of illusion. Flusser states that the function of technology is to defraud nature:

> This is the basic design of all culture: to defraud nature with technological means, to replace what is natural with what is artificial, and to build the machine through which the god that we ourselves are is revealed. In short: The purpose behind all culture must deceive sufficiently to transform simple mammals conditioned by nature into free artists. (Flusser, 1999, p. 19)

In fact, technique, technology and their mastery are indispensable means for the hybrid, intermediary process developed in this PhD. Heidegger (1977) recalls two statements about technology, which he considers inseparable: technology is a means to an end; and technology is a human activity. For Merleau-Ponty (2012, 1974), technique is the mediator of our embodied experiences and perceptions of the world. According to Funk (2012), technique consists of sensory-motor and ori-

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243 With a different argument, Roochnik (2013) seems to question the functionality of scientific knowledge: 'The universe studied by mathematical physics tells us nothing about the 'meaning' of our lives, about space and time, the world in which we live. It leaves no special place for ordinary human experience. […] In fact, liberation from a purely human perspective is the source of all the success and pride of modern science' (p. 3).

244 Translation by the author from the original: *'This is the design that is the basis of all culture: to deceive nature by means of technology, to replace what is natural with what is artificial and build a machine out of which there comes a god who is ourselves. In short: The design behind all culture has to be deceptive (artful?) enough to turn mere mammals conditioned by nature into free artists.*' (Flusser, 1999, p.19)

sensory experiences. Technique is the mastery and control of technology. As Steve Jobs (Jobs, 2011) stated, '[t]echnology alone is not enough. It is technology married with the liberal arts, with the humanities, that yields the outcome that makes our hearts sing.'[245] Glusberg (1980), referring to the proper application of technology and science in art, stated that the only genuine engine of creativity is the human element. In other words, technology itself has nothing to say, but people do.

As homo sapiens, we have been exploring technologies for hundreds of thousands of years. Technologies enable various forms of communication. The choice of technologies allows ideas to be articulated, giving them nuance and variation, while simultaneously highlighting the role of the aesthetic decision-maker (who chooses from among the various available options), which gives the technique its own dignity. Truckenbord (1992) writes: 'Artistic sensibilities, such as the perception of harmonious relationships, do not emerge from a medium, but rather from the artist's consciousness and are evident in the media in which the artist chooses to work.' The power of technique determines the constitution of our experience, underpinning its affinity with aesthetics. Technology is the final mediator between the author's idea and their audience. If we consider the sense of transmission in a communication flow, technology is the last point of contact with the receiver; if we consider the sense of reception, then technology is the first point of contact, that is, technology is the threshold between the extremes of a communication model or any model of knowledge acquisition and construction.

Thus, according to what has been described earlier in this text, it can be said that intermediary dynamics operate precisely at the threshold of the media, in the interstitial[246] space-time. This transformative operation is

245 Translation by the author from the original: '*[...] technology alone is not enough. It is technology married with liberal arts, married with the humanities, that yields us the result that makes our hearts sing*.' (Jobs, 2011)

246 Interstitial in the sense referred to by Roy Ascott (Ascott, 2013), i.e. any practice that takes place between, and not within, the familiar boundaries of any genre or medium.

Technologically mediated, just as our experience in the world is also constantly mediated.

TECHNOLOGY, PERCEPTION AND KNOWLEDGE

Let us return to the discussion of the polarisation of knowledge, understanding and perception, which began with the dispute between Plato and Aristotle. Plato, in an approach that could be described as 'top-down', completely devalues the epistemic dimension of the body; for him, knowledge is a process of recognition rather than cognition. His 'Theory of Forms' is an idealistic proposal of an immutable world of pure forms, of eternal ideas, which we only remember throughout our lives. For Plato, learning is remembering, and both truth and objective knowledge do not belong to everyday sensory life, as the philosopher does not value the practical knowledge of sensations and gestures. On the contrary, Aristotle, in a more realistic approach, values the human body much more and argues that with our senses we could identify all the natural forms of planet Earth, that is, we could rely on our sensory perception to construct explanations of the world.

It is appropriate at this point to affirm the relationship between sensory perception and technology and its importance in the observation and transformation of nature, that is, in the hybrid act, which is the acquisition and construction of knowledge. It is indisputable that the word technology derives from the Greek *techné*. Based on this assumption, Rojcewicz (2006) considers that technology is primarily a matter of our understanding of being, a question of what we need in order to be beings. Flusser (1999) considers that the greatest revolutions in humanity are technological and points to four main revolutions: human being and hand; human being and tool; human being and machine; and human being and robot. According to his analysis of the philosophical approach

Heidegger's sophical view of technology, Rojcewicz concludes that technology is the most basic and direct form of knowledge, of which science is merely an application. In turn, Funk (2012), in his philosophical analysis of the study of subjective and objective perception, observes a spectral situation in which *episthémé* is at one extreme and *te-chné* at the opposite extreme. He juxtaposes another spectrum to this one, matching each extreme with subjectivity and objectivity, respectively. To conclude his association, Funk juxtaposes a third spectrum, the 'classical' one, consisting of 'knowing that', 'knowing how' and 'competence' in knowing how to do. Funk demonstrates that *episthémé* — knowing that — is related to semantics and *te-chné* — competence — to gesture, embodiment and tacit knowledge of the competence of knowing how to do. Funk argues in his thesis that in human life, more important than the judgements that can be made about sensations is the capacity for orientation and practical success in everyday life. And this practical success is undoubtedly *techné*. Funk's philosophical criterion, certainly in continuity with Heidegger's thinking, clearly values embodied practice rather than theoretical ideas. Rojcewicz (2013), in analysing how the world reveals itself to us human beings (how we perceive it), considers that *technê* is not distant from the 'revealing gaze', in the same way that practice can be separated from theoretical knowledge. For this philosopher, *technê* is a matter of knowledge. As Heidegger (1995, 1990) states, *technê* is not a concept of doing, but a concept of knowing. In his analysis of Heidegger's interpretation of Aristotle's *episthémé/techné* dichotomy, Rojcewicz concludes that the distinction is based on what each reveals and how it reveals it. *'Episthémé* reveals what is unchangeable, techné what is changeable. [...] *Episthémé* is literally pure and simple knowledge: it is knowledge of what is simple (of the eternal and the unchangeable), [...] *Techné*, in contrast, is

247 See Heidegger, M. (1977). *The Question Concerning Technology and Other Essays*. (W. Lovitt, Trans.). Garland Publishing.

248 Practical success that depends directly on what we are capable of doing.

episthémé is knowledge of changeable things; […]'[249] (Rojcewicz, 2013, p. 60). Given that in the context of this research, both intermedia and research itself are transformative acts, which alter and depend on the changeable, it becomes evident to associate them with *techné*. Furthermore, the materiality and diversity of the means involved in intermedia synthesis imply a more objective, direct, mechanical, dynamic, technical, technological, active type of knowledge based on perception and motor [skills] for their manipulation and transformation.

The theory is inseparable from the knowledge just described, as it does not involve routine activities but rather practical knowledge that implies theoretical involvement in its broadest sense of observation, contemplation, speculation, and abstract thinking about facts. Annas (2011) even speaks of a 'flow' as the element that distinguishes routine activity from *practical expertise*. The author considers that this 'flow' is produced when people are intensely involved in an activity that requires concentration and competence to the point of losing awareness of themselves. According to the author, this 'flow' justifies the enjoyment and satisfaction obtained from acquiring/producing practical knowledge that is not obtained in routine tasks.[251] In fact, this theoretical-practical, pleasant ['flow'][252], felt in the practice of the transformative activity that is the intermediary process, may be one of the strong motives for the research that led to the materialisation of the works produced in this doctoral thesis.

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249 Translation by the author from the original: *'Episteme discloses what is unchangeable, techie what is changeable. […] Thus episteme is literally knowledge pure and simple: it knowledge of what is simple (the eternal and unchangeable), […] Techne in contrast to episteme, is knowledge of changeable things; […]*' (Rojcewicz, 2013, p.60)

250 This type of knowledge is what Polanyi (2009) called tacit knowledge.

251 Adaptation by the author from the original: '*[…] persons engaged in the activity lose awareness of their selves—that is, they cease to be aware of themselves as performing the activity. […] 'Flow' is produced when we have a combination of intense focus and loss of self-consciousness. […] Routine activities do not characteristically produce 'flow', since there is nothing requiring focus and engagement. It is intense engagement in skilled and expert activities that produces the loss of self-consciousness characterising flow. We have here an interesting empirical confirmation of a nutritive distinction between routine habits and practical expertise, namely, that the latter are characteristically enjoyable, and the former are* not' (Anna, 2011, p. 108).

252 The importance of flow is described in greater depth in the section 'The flow of playing while investigating'.

Still along these lines, theory in its broad sense (observation, contemplation, speculation and abstract thinking about facts) is inseparable from perception, which depends on the bidirectionality of our senses as sensors and actuators. In this regard, Funk states that perception is *techné*. In fact, it is through our senses, through *techné*, through technique and technology, that we can observe, contemplate and even transform nature. Rojcewicz states, 'Modern technology is theory, the knowledge of nature, and modern science is its application. Therefore, technology is not applied science; science is applied technology, applied ontological knowledge'[253]. In other words, Rojcewicz, like Heidegger, considers that technology precedes and triggers science[254]. Technology even allows for the convergence of previously separate academic traditions (Fornäs et al., 2002). Flusser (2010) refers to a complex mutual motivation between technique and the consciousness of those who use it: 'A consciousness in the process of transformation calls for innovative techniques, and an innovative technique transforms consciousness.'

Dunning and Woodrow (2007) associate technology with the very conception of body and mind: 'Technological invention has not only influenced how the body and brain are visualised, but perhaps more importantly, it has predisposed the way in which the body and brain are conceptualised'[255]

When we manipulate any technology, the criterion of perception is, as Funk (2012) states, the practical success of the operation of our bodies, the

253 Translation by the author from the original: *'Modern technology is the theory, the knowledge of nature, and modern science is the practical application. Thus modern technology is not applied science; science is applied technology, applied ontological knowledge'* (Rojcewicz, 2013, p.115).

254 Hidegger (1995, 1990), relating science to technology, particularly in the observation of nuclear physics phenomena, summarises that 'technology is co-determinative of knowledge' and denies the precedence of science over technology: '[...] the current conception of the relationship between natural science and technology should be abandoned: natural science would not be the basis of technology, but modern technology would be the fundamental structure supporting modern natural science'.

255 Translation by the author from the original: *'Technological invention has not only influenced the way in which the body and brain are visualised, but what is perhaps more important is that it has predisposed the way in which the body and brain are* conceptualised' (Dunning and Woodrow, 2007, p.46).

which is related to embodied tacit knowledge rather than propositional knowledge.

In fact, the practical research and knowledge developed in this study depended essentially on the research and development of skills, in a process of reciprocal improvement between perception and transformative action. The next section will discuss the inadequacy and insufficiency of literature as a means of recording and systematising the theoretical and practical knowledge constructed in the present research process.

TACIT KNOWLEDGE, EXPLICIT KNOWLEDGE AND UNWRITTEN THEORY.

The statement 'We know more than we can say'[256] (Polanyi, 2009) summarises in very general terms the concept of tacit knowledge proposed by Michael Polanyi, which could be summarised in the context of this investigation as competence for perception and action. As Polanyi himself exemplifies, 'we can recognise a face clearly without being able to say exactly what features of that face triggered that recognition'.

Polanyi proposed two dimensions within the totality of human knowledge, which Nonaka (1994) compares to an iceberg. At the tip of the iceberg is explicit, propositional, codified knowledge that can be expressed in words and numbers and is therefore transmissible in formal systematic language. Howlett and Morgan (2010) consider it 'conveniently much easier to study'. The rest of the iceberg, the overwhelming

256 Translation by the author from the original: *'We had envisaged tacit knowing in the first place as a way to know more than we can tell.'* (Polanyi, 2009, pp. 17–18)

Most of its volume, in this case, the overwhelming majority of knowledge, consists of tacit knowledge, deeply rooted in action, commitment, contextual and individual involvement, which cannot be symbolically codified to be transmitted in a discrete manner. According to Howlett and Morgan, given the complexity and elusive nature of tacit knowledge, it can only be seen in action. These authors note that there is still a tendency to consider the epistemic value of tacit knowledge insignificant. Funk selected the following pair of explanations for this dimension of knowledge: 'A peculiar combination of skilful competence and knowing is present in the work of our senses.'[257] (Polanyi, 1969); 'Perceptual experience acquires content thanks to our possession of bodily skills. *What we perceive* is determined by *what we do* (or what we know how to do); it is determined by what we are *ready* to do.'[258] (Noe, 2004, p.1). To paraphrase Noe, perceiving 'is implicitly understanding the effects of movement on sensory stimulation'.

Nonaka (1994) adapts Polanyi's concept of tacit knowledge and divides it into 'technical tacit knowledge' (know-how and skills) and 'cognitive tacit knowledge' (mental models of the world[259]). Cognition, according to Eysenck and Keane (2010), is a set of internal processes involved both in constructing meaning in a given environment and in deciding what action is appropriate in that environment, i.e., it is fundamental to the apprehension and construction of knowledge.

It is important to note at this point that, according to Biggs (2004), cognitive content is not necessarily synonymous with forms

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257 Author's translation from the original: *'A peculiar combination of skillful doing and knowing is present in the working of our senses*.' (Polanyi, 1969, p. 126)

258 Translation by the author from the original: *'What we perceive is determined by what we do (or what we know how to do); it is determined by what we are ready to do*.' (Noe, 2004, p. 1)

259 Nonaka uses the term 'mental models' chosen by Johnson-Laird (1983) to refer to cognitive elements in which human beings form operational models of the world with which they create and manipulate analogies in their minds.

linguistic. According to the arguments presented above, it can be argued and affirmed that tacit experiential (techno-cognitive) knowledge is theoretical-practical knowledge. However, Biggs seems to associate theory with verbal language when he states that ‘one of the reasons why it is not always possible to make the transition from practice to theory is because of language limitations. [Because] language cannot express everything.' But theory is not articulated exclusively through verbal or mathematical language. It is possible to theorise and think without resorting to alphanumeric symbols. Bermúdez (2007) proposes a theory of thought without words, non-linguistic thought, according to which all human beings begin their lives as non-linguistic beings. Biggs explicitly assumes that, in the academic context, research that can be communicated or disseminated is more desirable than research that cannot be communicated or disseminated, as the former will have a greater impact in its field.

The question that immediately arises is: how can research that is conducted and results in essentially tacit knowledge (technical and cognitive) be disseminated in an academic context (which favours explicit knowledge, which implies linguistic knowledge) when written languages (verbal and mathematical) are not adequate? Flusser (2010) writes: ‘All writing is terrible by nature: it deprives us of representations through images that predate writing, it tears us away from the universe of images that, in our pre-literate consciousness, gave meaning to the world within us’ (p. 29). This philosopher sees writing not as the expression of a compact thought, but rather as the expression of a [discursive] and historical thought. When he states that writings are not the appropriate code for observation and contemplation, Flusser considers images to be much more appropriate for these ‘tasks’, countering the prevailing tendency to consider the written word as the best means for articulating, recording and disseminating theory. For Flusser

260 Helm (2005) states that conservative societies such as capitalist consumer societies are dominated precisely by discursive means.

Being the alphabet is the rejection of ideographic writing, which motivates iconoclastic thinking. Ironically, but with a grain of truth, Wen-ders (2013) refers to his golden rule for making a film: 'Fewer words are always better'[261], or Heidegger (1995) when he objects: 'What do words matter if it is things that are at stake? Despite considering language and languages to be the greatest achievements of the spirit, Flusser speculates that 'the connection of thought to languages has atrophied our extraordinary capacities for abstraction', so that these capacities have only developed 'in the area of mathematics and symbolic logic'. This philosopher argues that the transition to alphabetic writing may have impoverished language, given that 'the alphabet does not record spoken language, it annotates it, […] regularises and organises what language means: thought'. Helm (2005), reflecting on Flusser's philosophy, affirms the conventionality of the alphabet and syntax: 'Human beings are capable of converting mere phenomena into symbols. What they need are conventions to give meaning to phenomena, transforming them into symbols. A symbol is a simple phenomenon that represents, by convention, another phenomenon'[262] (p. 447). In other words, according to Flusser, the alphabet was invented as a code of historical consciousness and to represent concepts rather than ideas. In his view, thinking based on writing is responsible for the crisis and doubt of that very thinking.[263]

In the context of academia today, however, the written word continues to have the greatest credibility when it comes to transmitting knowledge resulting from research. The following sections explain how tacit knowledge can also be transmitted and how

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261 Translation by the author from the original. 'Fewer words are always better' (Wenders, 2013)

262 Translation by the author from the original: *'Man is able to change mere phenomena into symbols. What it needs are conventions to give meanings to phenomena, thus changing them into symbols. A symbol is simply a phenomenon that represents, by convention, another phenomenon.*' (Helm, 2005, p. 447)

263 This thinking radically changed the concept of theory, which ceased to mean 'passive, religious contemplation of eternal forms' and came to mean 'advanced modelling of increasingly better types […] Theories offer knowledge, but they are creations. This problem, which lies at the heart of scientific experience, is one of the origins of the current crisis in historical thought' (Fluser, 2010).

The results of research in/by transformative practice contain, transmit and generate knowledge.

TRANSMISSIBILITY OF TACIT KNOWLEDGE AND CONSTRUCTIVIST DESIGN

The transmissibility of tacit knowledge has been the subject of debate in academic circles, with both critics and enthusiasts. According to Biggs (2004), verbal diksis[264] is more vague than gestural diksis, and conceptual diksis is the most opaque of all. For this author, the weakness of dialectic activity is its semantic ambiguity. In this sense, gestural díxis, *techne* and embodied tacit knowledge are more objective, but at the same time they are also subjective, because each human being has their own body and respective embodied knowledge.

In turn, Gourlay and Nurse (2005) consider it difficult to communicate or share tacit knowledge given its personal nature, as it is deeply rooted in action and involves engagement and a specific context. The answer to the question raised above (how to disseminate research that results in tacit knowledge?) is very simple: the audience, the target of this research, must be tacitly capable of doing so, that is, they must possess tacit knowledge that allows them to understand the results of the research in question. This idea is supported by Polanyi's (1969) statement that 'tacit knowledge depends on being tacitly understood' and by Noe's (2004) statement, already mentioned, that 'What we perceive [...] is determined by what we are ready [able] to do.'

264 Dixis is a structural element of language that is related to the context of the language itself. According to O'Keeffe et al. (2011), dixis refers to the way speakers orient themselves and their listeners in relation to the context of a conversation.

Although tacit knowledge is considered by many scholars to be untransferable because it is personal, it can be understood even without being repeated or reproduced. Take, for example, an impressionist Monet or an expressionist Munch. Any human being who has used and is familiar with the tools (brushes) and materials (oils) with which these artists created their works will find it much easier to perceive the differences in the gestures between these two artists. Because it is their gestures that made these men such important figures in the history of art. A drawing is just a two-dimensional graphic record of a gesture (or several) and those who draw, those who have the skill to do so, are able to understand the qualities of other drawings much better. It is, in fact, a question of aptitude, of how we deal with our bodies. Based on Leroi-Gourhan, Gill (2012) recalls that humans invented themselves as human beings through the techniques of the body that accompany the invention of tools, which in the context of the present research are also means. Still quoting Leroi-Gourhan, Gill writes that 'the hand has a gesturality that produces kinesthetic, proprioceptive and haptic knowledge.' According to Gill, gestures connect muscles to the mind. Funk (2012) considers that the knowledge and understanding of how to play the piano (by a competent pianist) is comparable to that of 'handling'/manoeuvring the body, and states:

> I think that with handling televisions, computers, and other tools, it is the same. The criterion of what we perceive is practical success in handling our bodies. This is related to *embodied tacit knowledge,* which is not the same as *propositional knowledge*.[265] (Funk, 2012, p. 3)

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265 Translation by the author from the original: *'I think with handling televisions, computers or other tools it is the same. The criterion of what we perceive is practical success in handling our bodies. This is related to embodied tacit knowledge that is not the same as propositional knowledge.*' (Funk, 2012, p.3)

Gourlay and Nurse's analysis of Nanaka's thinking contradicts the idea that tacit knowledge is untransferable, concluding that tacit knowledge is created through socialisation and internalisation. According to the authors, socialisation refers to the transfer of tacit knowledge from one person to another. However, for this transmission to be successful, it is necessary for the person who did not initially possess the tacit knowledge to create it (Gourlay and Nurse, 2005).

In the academic context, research is recognised as systematic inquiry, the aim of which is to produce communicable knowledge, as Archer (1995) specifies, it must be 'communicable because its findings must be intelligible, located within some framework of understanding, for an [appropriate] audience.'

Of the various categories of research activities traditionally recognised in the field of scientific research, 'action research' is the one that best fits the research and investigation carried out in this PhD. Archer characterises 'action research' as 'systematic investigation by practical action designed to develop or test new information, ideas, forms or procedures and to produce [communicable] knowledge'. The intermedia works resulting from the systematised action in the process of reflective practical research, developed during this PhD, also result in new forms of artistic (audiovisual) expression and, as such, are instrumental in nature.

Artistic expression usually depends on one or more instruments. The construction of the instrumental component of the aforementioned works involves the

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266 Translation by the author from the original: 'communicable because the findings must be intelligible to, and located within some framework of understanding for, an appropriate audience' (Archer, 1995, p.6).

267 Translation by the author from the original: *'Systematic investigation through practical action calculated to devise or test new information, ideas, forms or procedures and to produce communicable* knowledge' (Archer, 1995, p. 6)

interaction of design (in various [aspects]), computer programming, data mapping, conceptualisation, construction, among other tasks. In this sense, and given its constructive nature, the present research can also be framed within the field of Design Research through [Practice], more specifically, in what Koskinen et al. (2011) recently termed Research/Investigation through and in Constructive Design.

The works created in this PhD are systems — artistic systems, intermedia systems or artistic intermedia systems. As such, they are also works of design, since the term design, despite its ambiguity, precisely covers the planning of products or systems (Koski-nen et al., 2011). Archer considers that there are circumstances in research where 'the best or only way to clarify a proposition, a principle, a material, a process or a function is to try to construct or *enact* something, designed to explore, embody or test it'.[270] In this sense, the practical research developed in this PhD is also constructivist design, not only in the theoretical and philosophical sense, but mainly in a concrete sense, 'in which something is actually built and put to use. Not just concepts, but materials. Not just bits, but [atoms'271] (Koskinen et al., 2011).

Constructivist design practice results in objects, which in the specific case of this research are part of intermedia artworks. As Perrusi (2004) states, technically improving an object means improving its function and, at the same time, the gesture required to realise its functionality. From Leroi-Gourhan's interpretation, the author

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268 Some examples include human-computer interaction (HCI) design, software design, sound design, lighting design, equipment design, graphic design, and communication design.

269 *Design Research through Practice*

270 Translation by the author from the original: *'There are circumstances where the best or only way to shed light on a proposition, a principle, a material, a process or a function is to attempt to construct something, or to enact something, calculated to explore, embody or test* it' (Archer, 1995, p.11)

271 Translation by the author from the original: '[...]something is actually built and put to use. Not only concepts, but materials. Not just bits, but atoms.'

considers technical evolution to be equivalent to the history of the optimisation of the function of objects and that this optimisation process occurs concurrently with the aestheticisation process of these same objects. Therefore, objects in the aforementioned intermedia works relate technique and aesthetics. The following section discusses how these works, as a result of the research itself, communicate and transmit knowledge.

OBJECTS AS GENERATORS AND CONTAINERS OF KNOWLEDGE

The works resulting from the process of reflective practical research developed in this PhD are the result of the research itself, which was identified in the previous section as constructive design. These works are simultaneously the most efficient means of communicating and transmitting the knowledge produced in their constructive process.

Bang et al. (2012) state that constructive design, as a research/investigation process, allows knowledge to be produced based on the skills and capabilities of the design field in question. Chow (2003), when he states that 'to be a designer, a person has to do design', seems to echo Flusser's (1999) thinking, which can be applied to any activity: 'a shoemaker does not just make leather shoes, he also makes himself a shoemaker'[272]. The example of the shoemaker and the shoe can serve to illustrate the conclusion to be drawn regarding practical research and tacit knowledge. Consider a shoe resulting from a practical research process. That object will contain all the evidence of the knowledge applied to it, as well as evidence of new knowledge that has been constructed during the process of research and materialisation. Therefore, that shoe can communicate these co-

272 Translation by the author from the original: 'a shoemaker not only makes leather shoes; he also makes a shoemaker out of himself' (Flusser, 1999, p.44).

knowledge and disseminate it. The point is that this knowledge will only be accessible to those who know the state of the art of shoemaking. Those who possess this knowledge will be able to look at a shoe and tell whether it is traditional or innovative. In the case of an innovative shoe, the person who identified and understood the innovation has acquired new knowledge without having to repeat all the steps involved in making that shoe. In other words, the object itself, resulting from the action of tacit knowledge, has become explicit, a source of explicit knowledge. This example is only intended to demonstrate the possibility of transmitting knowledge through objects and achievements without involving a written text. Objects and achievements, and not just texts, are also capable of making us think and, consequently, are capable of containing and generating knowledge. Hjelm (2004), in her article 'Artefacts as research', argues precisely that an object, as the materialisation of an idea, contains and transmits knowledge just like a written academic document. According to this researcher, knowledge is not something immaterial. It needs to take shape in order to be understood by human beings. This shape can be either a product or a written article or report. A product or a work of art is informed by knowledge and embodies knowledge (aesthetic, technical, ergonomic, among others). We reiterate what was stated regarding the need for prerequisites for the audience/target and evaluators of research that is essentially practical: 'The knowledge embedded in the artefact, [written] article or [work] product is not, however, immediately available to everyone. A certain prior knowledge of the subject and knowledge of how to 'read' and interpret the artefacts is necessary'273 (Hjelm, 2004, p.3). This knowledge of how to read and interpret the artefact corresponds to the experience of 'conversation'274 with situations and objects, experienced in the practice of design and artistic production, that is, what Jahnke

273 Translation by the author from the original: *'The knowledge embedded in the artefact, the paper or the product, are however not readily available to anybody. It requires a certain pre-knowledge of the subject and knowledge about how to "read" and interpret the artefact'* (Hjelm, 2004, p.3)

274 We suggest reading Schön (1992), who dedicates an article precisely to conversation with subjects and materials. Note that this is not a conversation about subjects or materials, but rather with them.

(2012) refers to this as hermeneutic practice. To support this idea of ‘conversation’, it is argued that the creation and production of art and/or design are acts of questioning rather than answering, as suggested by Gadamer (2004), ‘[e]very sudden idea has the structure of a question.’[275] This conversation and questioning have iterative characteristics, as stated by Attar (2010), who sees this conversation by the practitioner as a transaction with the subject matter and materials.

> When dealing with the materials of a situation, practitioners encounter surprises in the form of 'responses' that momentarily interrupt the action, evoking uncertainty. Triggered by shock, surprise, excitement, the unexpected, or accident, reflective practitioners think 'without a safety net' in the midst of the action to frame and reframe the puzzle situation. Reflective practitioners progress iteratively to transform these situations in a way that resolves uncertainty [...] They find themselves in a unique process of reciprocal transactions with the situation. They are influenced by their appreciation while shaping it as their thought and action.[276] (Attar, 2010)

This passage by Attar can also substantiate and reinforce two fundamental characteristics of the intermediate works: the indeterminacy discussed in a previous section and the iterative nature of the methods used in the conception and production of the three works developed in this doctoral thesis. In fact, the iterative nature of the methods of reflective practice is also theoretical.

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275 Translation by the author from the original: *‘Every sudden idea has the structure of a* question’ (Gadamer, 2004, p.360).

276 Translation by the author from the original: *‘In dealing with the materials of a situation, a practitioner encounters surprises in the form of 'back-talk' that momentarily interrupts action, evoking uncertainty. Triggered by shock, by surprise, by excitement, by the unexpected, or by the happy accident, reflective practitioners 'think on their feet' in the midst of action to frame and reframe the puzzling situation. Reflective practitioners iteratively go on to transform such situations in a way that resolves uncertainty, […] They are in a unique process of reciprocal transaction with the situation. Influenced by their appreciation of it at the same time that they shape it by their thinking and doing, […]*’ (Attar, 2010)

rich, it also involves constant thinking, questioning and analysis of the results of actions.

It is therefore essential to state that the works resulting from research through reflective practical actions accurately communicate and convey the results of the research itself. The next section describes the process of reflective practical research, associating it with doing, not as an act of mere execution, but as the act of producing what had not been done before, reinforcing the importance and influence of materials in this type of research process.

REFLECTIVE PRACTICE, DOING AND MATERIALS.

The dynamics of intermediate production result primarily from reflective practical research. To support this statement, reference should be made to the contribution of Edmonds and Candy [277] (2010). These authors consider that the structure of the practical research trajectory (in art and design) is defined by the invention of artists/designers and by the purpose of the research: to model the development of artistic work.

The structures developed to guide practice and evaluate the results of that practice are the artefacts produced which, as structures, become guiding criteria for the creation of new works or artefacts. As Edmonds and Candy suggest, the criteria that emerge from conscious reflective practice are used to guide the next iteration of the design of the work or new works: 'the results of the evaluation and refined structure are used to inform and guide the next work'. This 'next work' may be by the author themselves or by

277 These authors propose a model of the trajectory of research-related practice with three fundamental elements: the practice from which the works (installations, performances and artefacts) result; the theory that produces criteria and structure; and the evaluation that produces results.

any other. This possibility reinforces the idea that we wish to defend: the works produced in this PhD are, in themselves, a contribution to knowledge and can serve as a reference and inspiration for other authors.

Edmonds and Candy argue that the questions and subjects of (practical) research arise naturally from practice, becoming small steps towards articulating the context and methods associated with the practice itself. ‘With each iteration in practice, the artist moves towards their goal of creating works of art that elicit particular responses in the audience; like a scientist, they test hypotheses embodied in the work under consideration at the moment.’[278] Thus, it can be reaffirmed that practice is also an act of questioning. The practice, as research in this PhD, resulted in at least three intermedia works which, as experimental systems, simultaneously take the form of questions and answers. Rheinberger (1998) considers experimental systems as research units ‘designed to answer questions that we are not yet able to clearly ask’. Quoting biologist François Jacob[279], who defined experimental systems as systems that generate expectations, equating them to ‘machines for making the future’, Rheinberger defines these systems as devices that ‘not only generate answers but — as a prerequisite — shape the questions to be answered. An experimental system is a device for materialising questions’ (p. 288).

Design and art are, therefore, the materialisation of questions, answers, and ideas, and ideas do not arise unexpectedly because, as Gadamer states, ideas, even if sudden, 'presuppose an orientation towards a

278 Translation by the author from the original: 'With each iteration in practice, the artist moves toward her goal of creating art works that stimulate particular responses in the audience; much like a scientist, she is testing the hypothesis embodied in the work under consideration at the time'.

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area of openness from which the idea can occur'[280]. Brook (2008) certifies that the work of developing artistic work 'involves reflection, which means comparing, incubating, making mistakes, going back, hesitating, starting over'. Therefore, artistic and design practice are in fact reflective, thoughtful and theoretical acts. The simple recognition of the properties of a material involves asking questions, as Gademer exemplifies, for in order to recognise, it is necessary to question 'whether it is this or something else'. Weissensteiner and Freksa (2012) refer to an artist as someone 'interested in the semantics of materials', while Moravanszky (1996) notes that, although rarely discussed by historians (of art and architecture), the semantics of materials ensure an important part of the meaning of works. As early as 1980, Glusberg (1980) noted that the revolution brought about by intermedia is based on the transformation of technical elements into means of communication and meaning.

These arguments corroborate that the very materiality of the work is an informative and intelligible dimension of it; it is language, non-verbal, indescribable, yet communicable and transferable as required by the classical academic scientific method. The work, as the result of practical research in art and/or design, simultaneously communicates and transmits the results of the research. The condition for this transmission to be successful is that the receiver, the target of the research, knows, masters or is minimally receptive to the language or languages used. Already in the 18th century, Diderot (1782) considered technology to be the 'language of the arts'. Deleuze (1987) also maintains that artistic creativity is dependent on and intrinsically linked to means of technical expression and technical knowledge, when he states that 'ideas are potentials immediately involved with a mode of expression [technique]. Depending on the techniques I know, I can have an idea in that domain.' Deleuze effectively affirms the power of technique and technical knowledge as

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280 Translation by the author from the original: *'They [ideas] always presuppose an orientation toward an area of openness from which the idea can* occur' (Gadamer, 2004, p.359).

driver of creativity. In other words, in order to have an idea in a given field, it is necessary to have prior knowledge of the techniques in that field. This is to say that the only people capable of constructing an idea in photography are photographers, the only people capable of constructing an idea in music are musicians, and the only people capable of constructing an idea in intermedia are intermedia practitioners. In this sense, it is argued that in order to understand the results of research in the field of intermedia practice, both the target and the evaluator of the research should preferably be experienced connoisseurs of intermedia practice. Based on Deleuze's statements, intermedia thinking and construction are therefore exclusive to practitioners of intermedia technique.

Sullivan (2009) affirms practice as research and describes it as thought. With similar arguments, Daichendt (2011) understands that academics who share this perspective understand practice (artistic or design) as 'an intelligent process that is configured similarly to the research used to understand phenomena in the qualitative tradition'.[282] According to Daichendt, it can easily be concluded that a textual, literary research process is simpler than a research process through artistic practice because, as the author states, it is 'a system more complicated than any language', 'a complex and multimodal way of investigating something'.

It is imperative to recognise practice as a form of research, it is urgent to validate practice as research within academia, it is essential to bring this practice into the heart of academia. Koskinen et al. (2011) refer to the unavoidable issue that today a PhD degree is a requirement for academic teaching. But, in fact, this was not how the en-

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281 This author defends artistic practice as research, qualifying artistic production processes as a research process. As he states, practice is research and the artist investigates through their practice. Daichendt considers artistic practice as thought and action in an artistic medium, with the results of research through artistic practice being presented in the form of creative products.

282 Translation by the author from the original: *'Scholars associated with this perspective understand art practice as an intelligent process that draws similarities to inquiry used to understand phenomena in the qualitative tradition.'* (Daichendt, 2011)

bell and the learning of art and design have continued to the present day. These authors regret that design and research have been considered as distinct 'pursuits', developed in different academic contexts, quite possibly for reasons of timing: 'Design was largely future-oriented; research focused on the past and present.'[283] Thus, in order to maintain the sensitivity of artists and designers, Koskinen et al. consider it essential that teachers of the future have skills, that is, that they are in fact artists and/or designers who actually produce art and/or design.

Zimmerman and Forlizzi (2008) support this temporal issue by stating that:

> By practising research through design, design researchers can explore new materials and actively participate in the intentional construction of the future, in the form of disciplined imagination, rather than limiting their research to the analysis of the present and the past.[284] (p. 4)

Artistic and design practice is increasingly recognised as an emerging field of study. In this text, we aim to affirm artistic practice and design practice as synonyms for Making art and Making design. Making as bringing into presence, to paraphrase Heidegger (1995, 1990), bringing here, to the manifest, that which was not previously given as present.

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283 Translation by the author from the original: 'Design was largely future-oriented; research focused on the past and the present.' (Koskinen et al., 2011, p.ix)

284 Translation by the author from the original: *'By practising research through design, design researchers can explore new materials and actively participate in intentionally constructing the future, in the form of disciplined imagination, instead of limiting their research to an analysis of the present and the* past' (Zimmerman and Forlizzi, 2008, p.4).

285 The term Fazer will be used with a capital letter to signify the English verb 'to make', which is not the same as 'to do'. The former is related to production, construction, creation of something new. The latter is more related to the execution of tasks such as 'cleaning the house'.

Tin (2012) considers Doing as an act of research that visualises the procedural aspect of understanding, as interaction/interpenetration between subject and object, between the trainer (who gives form) and the material conditions. This author considers that the most notable achievements and accomplishments in the 'disciplines of Doing' were achieved within their own educational and professional system (studios, workshops, schools and universities), that is, where the works 'were conceived and produced, far from the concerns of science and theoretical research'[286]. For Tin, Doing, in the academic context, can be approached as study/research; as an object of study/research; or as an integral part of a study/research. According to Tin, when Doing is not research, but rather the object of research, the result is always propositional knowledge. This is because scientific research is based on the principle of objectivity, which implies a distinction between subject and object. In other words, the object of research cannot be studied from a participant perspective, but only as an external observation, which creates an asymmetry between the research and what is being researched.

Daichendt (2011), drawing on Kant, considers that writing about artistic products is useful but denies the aesthetic appeal of the works themselves. Daichendt affirms the complementarity between 'aesthetic ideas' and 'rational ideas', which cannot communicate the same type of knowledge, when he writes: '[...] rational ideas presented in words [...] cannot be presented as art. […] Attempting to explain an aesthetic object will be unsuccessful because words will fail to recognise key aspects or aesthetic judgements.' [287] This complementarity suggests and motivates the emergence of a rapprochement between the two. Possibly in the sense of this convergence or hybridisation, Tin argues that the practices of Making (from art and design to architecture and music) can (and should) be

286 Author's translation from the original: '[...] *design have been conceived and produced, far from the concerns of science and theoretical research*.' (Tin, 2012, p.2)

287 Translation by the author from the original: '[…] *rational ideas that are presented in words […] cannot be presented as art. […] Trying to explain an aesthetic object will be unsuccessful because the words will fail to recognise the key aspects or aesthetic judgements*.'

integrated into scientific research, not so much as objects of study but rather as sui generis research methods. For this author, there are several factors that distinguish Doing as research, among which we highlight the fact that it is a process of creation and exploration, that it follows an orderly sequence of experiences and reflections, that it generates specific knowledge, and that it articulates meaning that can only be partially conceptualised.

Wilson (2003) dedicates a chapter of his book to the possibilities of art as research, where he considers that 'artists develop new types of knowledge and applications ignored by mainstream science and research corporations, pushing scientific research in unexpected directions'288. One of the major transformations that the integration of art and design practices can bring to academic and scientific research is the acceptance that the methodology itself and the 'rationalisation' of the 'problem' are inscribed in the process itself (artistic, design, production, research), rather than defining it. In other words, the method does not determine the research process but is determined by it. In this way, the (research) process becomes more fluid and self-regulating, reinforcing its autopoiesis.

Tin affirms the ubiquity and antiquity of Doing, considering it the practical dimension of culture that acts in the transformation of matter and articulates meanings. Carter (2004) associates the totality of a literary work with this theme, entitling it 'Material Thought', where he argues that material thought is an act of invention, an act of Doing. From this, we can affirm Doing as the materialisation of thought or as the material of thought (Vaughan, 2007).

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288 Translation by the author from the original: '[…]*artists develop new kinds of knowledge and applications ignored by mainstream scientific and corporate research and push scientific inquiry in unanticipated directions*.' (Wilson, 2003, p. 35)

It is also worth emphasising the importance of the material[289], which is a means, as well as a determining influence on the very process of creation and production of the intermedia works developed in this PhD. This means that any relationship with materials is in itself very inspiring. Higgins (1998) perhaps stated somewhat extremely that 'the artist does what the material suggests'. In the context of this paper, this statement is updated to 'the artist does what the material allows', adding that material thinking, associated with practical reflection, is an inexhaustible source of inspiration. This practical reflection generates and requires tacit thinking and knowledge based on the constant examination of 'practical experience of material goods and the cultivation of empirical knowledge about material qualities that can be achieved through practice and comparison'[290] (Freitas and Lutnæs, 2007).

Doing is much more than mere mechanical production. Tin considers that doing 'consists of a process [involving personal practice] of intentional training, the result of which is articulated meaning'. For this author, the transmission of practical skills occurs through practical experimentation rather than theoretical explanation. In other words, based on Tin's statements, the requirement for the transmissibility and reproducibility of knowledge generated in academic research would be safeguarded. This means that, in an experimental, practical, tacit context, what does not ensure 'reproducibility' is the attempt to describe this type of knowledge in the form of written verbal language. It can be concluded that in art, the reproducibility of an artistic experience will not be a matter of interest to researchers (artists and designers) who wish to develop new and original work.

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289 In the context of this research, the term 'material' is as broad as can be imagined, encompassing biological, digital, or conceptual materials.

290 Translation by the author from the original: *'they examine the practical experience of material goods and the cultivation of empirical knowledge about material qualities that can be achieved through experience, practice and comparison or* connoisseurship' (Freitas and Lutnæs, 2007, p.1)

The issue of research reproducibility will be discussed in the section 'Reproducibility and memetics'. The next section reaffirms Doing as an act of research and describes the intrinsic motivation that can be found in the act of Doing research through reflective practice, associating it with the challenging and liberating act of 'playing'.

THE FLOW FROM DOING RESEARCH TO PLAYING.

> That is the way to learn the most, when you are doing something with such pleasure that you do not notice the time passing.[291] (Einstein, 1915, as cited in Lawson, 2004, p.12)

> Play is the highest form of research. (Einstein, as quoted in Gestel et al., 2008, p.70)

Accepting that research is done and that one investigates by doing; considering that, under optimal conditions, both research and doing require total dedication and concentration, this section aims to demonstrate that artistic and design practice, as research, can be compared to the act of playing. Philpot (2013) investigates the playful nature of certain methods and procedures of research and experimentation in design. The author considers that research in the academic context is too risk-averse, too constrained, coercive and rigid to develop innovative and original ideas. She adds that the focus on documenting the

291 Translation by the author from the original: *'That is the way to learn the most, that when you are doing something with such enjoyment that you don't notice that the time passes*.' (Einstein, 1915, as cited in Lawson, 2004, p.12)

research and creation process, interrupts the flow of that same process, leading to a loss of spontaneity.

This idea of approaching work, research and development in art and design without constraints, as a game and/or play, brings optimism, enjoyment, positivity and freedom to the researcher and to the research itself, conditioning the results of this process. Philpot associates this playful character with certain research methods that allow for a spontaneous and unpremeditated approach. This enhances the indeterminate character of the intermediate work resulting from a process of research, experimentation, creation and production, based on a practice understood and assumed to have the playful character of games and play. Based on Philpot's analysis of the research, it can be concluded that the type of intentionality associated with the acts of playing and gaming cultivates a relaxed state of mind that allows for concessions and flexibility in control, allowing for the unknown. Philpot quotes Brown (2010) when she refers to the fact that human beings are not limited to 'a rigid way of doing things' and are 'open to serendipity and chance'. Supported by renowned educators, the author affirms play/gaming as a form of learning and self-teaching.

In the context of the works produced in this PhD, much of the development process takes on a playful character, like freely playing with materials, techniques and ideas. The works are the result of a passionate and disinterested practice that makes (artistic) work an enjoyable activity. Some of the intermedia works produced during this research are developed spontaneously and intuitively in a fluid and sometimes non-linear way. This type of production can be more easily related to play than to work, precisely because of its fluidity.

When we play, when we are totally immersed and concentrated on a task or activity, when we 'flow', we lose track of time, and this fact is incompatible with the modern notion of work, with schedules, goals, deadlines and other types of constraints. For Nakamura and Csikszentmihalyi (2002), what holds our attention shapes our experience, and through this, our consciousness and culture. For these authors, this ability to focus attention is the phenomenon that enables the union of action and experience. Nakamura and Csikszentmihalyi describe flow as a subjective experience of managing challenges, in which action is continuously adjusted based on feedback from the process itself, so that the experience evolves in a homogeneous manner. Although flow is an experience associated with intrinsically motivating activities, in fact, the practice developed in this research fostered a positive experience of both intrinsic and [extrinsic] motivation.

The ‘fluid’ experience of Doing the works (Greenray, ColMus, SoLu and SynDyn) was, in a way, shaped simultaneously by the researcher and the research context, in a kind of feedback loop that served as [an emergent] motivation, through the constant discovery of new interests. As Nakamura and Csikszentmihalyi state, ‘what happens at a given moment is a response to what happened in the immediately preceding moment in the interaction, rather than being dictated by an intentional structure located in the researcher or the context’ (p.91). For these authors, flow — which in the context of this PhD existed in the act of doing the works as research — has as a precondition

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292 The authors list several characteristics of flow, among which the following stand out: intense concentration on what one is doing at a given moment; the fusion of consciousness and action; the distortion of temporal experience; and the experience of the activity as intrinsically rewarding in such a way that often the result (work) is only an excuse to develop the process.

293 Rheinberg (2008) proposes different conceptualisations of intrinsic motivation. The most appropriate for the context of the activities carried out in this research is: ‘Activities are seen as intrinsically motivated when the main incentive lies in the performance of the activity itself, whereas in activities seen as extrinsically motivated, the greatest incentive lies in the expectation of their results’.

294 According to Nakamura and Csikszentmihalyi, motivation is emergent in the sense that goals arise from interaction. In the specific case of this research, it refers to the interaction inherent in the act of Doing.

The flow, as an emergent motivation, functions as an 'expanding force' of the researcher's structure of interests, as well as their skills in relation to those interests. An activity in which flow occurs 'provides a set of challenges and opportunities for action (Doing)' but also 'accommodates a continued and profound sense of well-being' simultaneous with the growth of the researcher's skills. 'Inherent in the concept of flow is the notion of skill extension,' the authors state.

In this sense, Doing as an act of research expands the researcher's competence, knowledge and learning, which, when materialised in works, become memetic[295] vehicles for recording and transmitting competence, knowledge and learning. At the very least, works are always sources of inspiration or influence for other artists, designers and researchers. It is also important to note that although flowing in Doing is a highly rewarding state, it should not be confused with relaxation. Achieving this state requires effort and commitment to the ability to focus attention on Doing.

Landhäußer and Keller (2012), who correct Csikszent-mihalyi's flow model, confirm from their scientific point of view that flow is not just fun, it is 'something much more specific'. These authors also conclude from their study that flow has positive effects on performance, in this case, in artistic activity, research and design practice. As such, flow is an incentive to do, and in the context of this research and the resulting works, flow was perhaps the greatest motivation. Schüler and Engeser (2009), who study incentives and the flow of human engagement in contexts of knowledge production, consider flow to be an affective state. These authors, from a classical perspective,

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295 The following section will present the concept of memetics associated with the reproducibility and transmission of knowledge.

Physics defines incentives as affective states that people expect to experience after or during the performance of a given action.

Philpot, supported by Csikszentmihalyi, considers that in addition to satisfaction, flow as a state of concentration 'opens up space for the development of new concepts and processes', so that when applied to art and design, flow can function 'as a method for increasing understanding and competence, for exploring potential applications for an object or process, or for synthesising and structuring information' (p. 2).

It can be concluded that the works resulting from the research process in this doctoral thesis were materialised precisely under an intense state of flow, which was undoubtedly (in)determinant in the design of the research process itself and, consequently, in its results.

REPRODUCIBILITY AND MEMETICS.

The reproducibility of research results has been the condition that validates research according to the scientific method. This reproducibility is ensured in the scientific and academic environment by *peer reviews*, but there is no consensus that this method is in fact accurate and objective.

Barton (2010) states, 'it seems that *peer reviews* are not convincingly reproducible […]. Reviewers tend to be mainly established authorities in their field , who may not be interested in disrupting the status quo.'[297] Richard (2000) also criticised the particularity of reproducibility in the scientific method: '[...] we know that the system

296 Evaluations of work done by people with similar skills to those who produced the work.

297 Author's translation from the original: '[…] it seems that peer review itself is not convincingly reproducible[…].' '[…] reviewers tend to be principally established authorities in their field who may not wish to upset the status quo.' (Barton, 2010, p.35)

peer review is biased, unfair, inexplicable, incomplete, easily fixed, regularly insulting, usually ignorant, occasionally senseless, and frequently wrong.[298] The academic industry is generally and directly regulated at the level of discipline-based departments (Kniffin and Hanks, 2013) that 'perpetuate the disciplinary system' (Abbott, 2001). In this industry, a hybrid, interdisciplinary and undisciplined area of knowledge such as intermediation finds it difficult to integrate and be evaluated.

In academia, with its tendency towards measurability, interdisciplinary research is more difficult to review and evaluate because, as Kniffin and Hanks state, interdisciplinary research 'is judged by people from a variety of disciplines who typically have conflicting measures of quality'.[299] Furthermore, as Wilson (2003) pointed out, *'peer review* panels for scientific journals are not always able to see beyond their disciplinary blinders'.

Wilson argues that many artistic, cultural and technological advances often occur outside academic channels. In other words, as he himself suggests, if culture depended solely on traditional lines of research, we would have to wait much longer for the developments that have profoundly changed the last few decades. At the end of the 20th century, Heidegger (1995, 1990) even considered the university to be 'probably the most sclerotic form of school' and 'the most backward in its structure'.

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298 Translation by the author from the original: '[…] *we know that the system of peer review is biased, unjust, unaccountable, incomplete, easily fixed, often insulting, usually ignorant, occasionally foolish, and frequently wrong*.' (Richard, 2000, p.148)

299 Translation by the author from the original: '*[…] "interdisciplinary papers are harder to review" since they are typically judged by people from a variety of disciplines who often have conflicting measures of quality*.' (Kniffin and Hanks, 2013, p.5)

300 Translation of the author from the original: 'The peer review referees of scientific journals cannot always see beyond their disciplinary blinders' (Wilson, 2003, p.35)

One could also speculate about some academic inconsistency regarding the criterion of reproducibility of research results. Reproducibility, which is one of the most important and valued principles of the scientific method, is not valued in the same way when considering tacit embodied knowledge and the old master-apprentice teaching method, which is based precisely on the same principle of copying and repetition. Because that is what it is all about, reproducibility is related to reproduction, copying, representation, recreation and imitation. Thus, academia upholds the classic statement: 'by copying, one also learns'. In the context of art and/or design, reproducibility can raise self-referential and ethical questions related to originality, but this is not the focus of the present discussion. The problem, then, is not the reproducibility of the research itself, but rather what is reproduced: a concrete solution to a given challenge, in the case of art and design, rather than abstract research into a general problem.

Another norm of the academic system, also related to reproducibility, establishes that the result of research must be a contribution to knowledge (Tinkler and Jackson, 2004). A PhD is the academic degree of Doctor of Philosophy. Philosophy in its broadest sense is the ‘love of knowledge’. As demonstrated in this text, knowledge is not limited to what can be described in words. Leroi-Gourhan (1964/1993) also considered that a significant part of human thought diverges from linearised (written) language when it attempts to understand that which does not lend itself to a rigorous notation system. Still on the subject of the written word, the same author states that it is a form of knowledge that is both linearised and fragmented, and therefore 'incompatible with the process of sustained thought'. Thus, it would be very reductive for (written) literature to be, in academia, the

301 According to Langrish (2004), the invention of the PhD (Junior Doctorate) originated in Germany due to the chemical industry's need to train organic synthesizers at universities to create new compounds. In other words, the PhD originated precisely in an area of research that was essentially practical, experimental and non-literary.

It is a privileged way to obtain a PhD degree, as well as a way to contribute to knowledge with new ideas and practices.

Contributing to knowledge also means contributing to cultural evolution. Evolution in the field of Arts and Design is the evolution of ideas[302]. The Darwinian evolution of ideas is called "memetics[303]" which is based on the concept of self-replicating ideas called memes[304] (Langrish, 2004). The concept of meme was proposed by Dawkins (2006) in 1976, describing it as a ‘unit of imitation’ responsible for cultural propagation.

Dawkins writes:

> The new soup is the soup of human culture. We need a name for the new replicator, a noun that represents the unit of cultural transmission, or unit of *imitation*. [...] I want a monosyllable that sounds a bit like 'gene'. [...] I abbreviate mimeme as *meme*.
> Examples of memes are melodies, ideas, mottos, clothes, fashions, ways of making pots or building bows. [...] Memes propagate in the meme pool by jumping from

302 According to Deleuze, one only has an idea in a given field depending on the techniques known in that field.

303 There is no consensus among academics as to whether meme theory should be selected and maintained or simply abandoned and forgotten. Edmonds (2005) considered that the memetic approach might not survive, based on the rapid decline in the number of articles written between 2002 and 2004 that included the term 'memetics'. However, using one of the tools employed by Edmonds (Google Scholar), it can be seen that there has in fact been an increase in the number of texts discussing this topic. Four years later, Edmonds himself (2009) now considers it possible that
emergence of a memetic process in his text 'The Survival of Memetics'. In 2011, Tim Tyler considers that 'memetics is an important science
' (Tyler, 2011) in the chapter 'Memetic takeover - Memes triumphant'.

304 Translation by the author from the original: '[...]*Darwinian evolution of ideas is called "memetics" from the concept of self-replicating ideas called memes*[...]' (Langrish, 2004, p. 4)

> brain to brain by a process that, in a broad sense, can be called imitation (p. 192) [305]

A year later, Hamilton (1977) affirmed the meme in the context of cultural evolution as equivalent to the gene in the context of biological evolution. Since then, several authors have contributed to the acceptance of the meme as a fundamental unit of human culture.

Although there are still opposing views on memes, some more sceptical and others more enthusiastic, Shifman (2013) considers that we live in an era driven by *hypermemetic* logic. This author, who explores the usefulness of memes in understanding digital culture, considers that the term describes cultural reproduction driven by imitation and copying. Shifman uses the meme to understand certain aspects of human culture, without focusing on the various meanings that the term has had over the years.

Wright (2010) considers cultural evolution to be the selective transmission of memes, [306] and Tyler (2011) reaffirms that 'memetics is just the genetics of culture'. [307] According to Blackmore (2000), memes are transmitted between human brains [308] also through objects. For this author, our behaviours and choices result from a structure of *memeplexes* (complex memes) that functions in a biological system.

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305 Translation by the author from the original: *'The new soup is the soup of human culture. We need a name for the new replicator, a noun which conveys the unit of cultural transmission, or a unit of imitation. […] I want a monosyllable that sounds a bit like "gene." […] I abbreviate mimeme to meme. Examples of memes are tunes, ideas, catch-phrases, clothes, fashions, ways of making pots or of building arches. […] Memes propagate themselves in the memes pool by leaping from brain to brain via a process which, in the broad sense, can be called imitation'* (Dawkins, 2006, p. 192).

306 Wright includes beliefs, habits, rituals, songs, technologies, theories, among many other things, in the category of memes.

307 Translation by the author from the original: *'Memetics is just the genetics of culture*.' (Tyler, 2010, p.143)

308 Blackmore relates genes and memes by stating that genes provide different types of brains that are better or worse conductors of different types of memes.

Given the elasticity of the meme, Kodish (2003) considers it the ideal label for products such as mathematical, scientific and literary formulas; words and doctrines; objects; inventions; media; artistic works; fashions; modes of behaviour, etc. For Reed (1996), memes are a system of actions and objects. There is consensus among several authors that objects are also memes (Reed 1996; Blackmore, 2000; Kodish 2003; Garfoot, 2005).

Tresilian (2004), who considers that memes are capable of capturing any semantic variation in the rational and irrational spectrums, identifies, in the universe of communication, attraction memes with functions opposite to those of distribution memes.[309] In the field of art, Tresilian (2008) proposes two types of memes that are fundamental to the present investigation: closed memes and open memes. According to Tresilian, closed memes are based on [objects], spatially exclusive, closed to events in the outside world. This group includes painting and sculpture, which normally involve looking at the work from the outside, a contemplative attitude and an individual aesthetic experience. In contrast, open memes are based on events, temporally inclusive, open to events in the outside world and extremely permeable. This group includes installation and contextual art, which involve looking from within the work, a participatory attitude and a communal ritual experience. Thus, based on the definitions proposed by Tresilian, it can be seen that the works produced in this research operated homogeneously between these two types of memes, as the simultaneous presence of the attributes of open and closed memes can be easily observed in the works in question.

According to Langrish (2004), memetic evolution in the world of art and design is a Darwinian evolutionary process, but one that is entirely

309 For a better understanding of the difference between sticky memes and soft memes, we suggest reading the text "Reflections on the Art-Historical 'Big Picture'" in which Tresilian associates sticky memes and soft memes with two orthogonal semantic axes, one relational and the other rational.

310 Consider an object as a permanent relationship between matter and space.

Unpredictable and indeterminate in the long term, as the ‘rules’ of competition change continuously and the success of replication (of memes) is subject to chance and whims. In 1999, Langrish (1999) updated the notion of *memes* and *memetics*, considering that memes should not be regarded as units but rather as patterns. This issue seems purely semantic, as unit also means plurality, i.e. the union of different elements, and as such a pattern is also a unit.

Langrish moves away from the idea of imitation and epidemiology[311], proposing three classes of memes: *recipemes, selectemes, and explanemes*[312]. Memes in each of these classes can be transmitted in different ways, with two of these classes being transmitted by imitation, without resorting to oral or written verbal language. Recipemes are (competitive) ideas about how to do things, and the most successful ones are replicated with or without modifications and additions (Langrish, 1999). ‘Selectemes are ideas about what kind of thing one wants to do. They are involved in decision-making between alternatives. They provide motivation; they are values.' (Langrish, 2004) Selectemes are basically ideas about the success, efficiency and excellence of recipemes.

The dynamics of the *recipeme* and *selecteme* classes substantiate and validate that the works resulting from this practical research developed in this PhD are indeed a contribution to knowledge. Thus, the three works in question, as materialisations of ideas resulting from decisions made between possible alternatives, are recipemes that can easily serve the selectemes of those who become aware of the existence of these works.

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311 According to Langrish (1999), the idea of an epidemic presupposes a polarity between humans and invaders, giving rise to a notion of the ‘self’ as the result of an ‘infestation’.

312 For a more detailed description of these three classes of memes, we suggest consulting Langrish's article 'Different Types of Memes: Recipemes, Selectemes and Explanemes'.

For the reasons stated above, works of art and intermedia design communicate their contribution to knowledge better than verbal descriptions can. Using the example of music, Langrish confirms this possibility when he states that ‘melodies can be transmitted by written music, but more often their transmission does not depend on symbols. Cymbals [from the drum kit] may be better than symbols for transmitting musical ideas.’

Although they originated in biology and were later disputed in various disciplines (psychology, philosophy, or linguistics), memes, according to Shifman (2013), should be considered from the point of view of communication, as they spread gradually through interpersonal contacts. And in fact, it is communication that is at stake. The reproducibility and dissemination of knowledge depend on communication. Therefore, the transmission of knowledge and the results of reflective practical research is an act of communication.

Most of the knowledge acquired and generated in this research is tacit and ineffable, and therefore cannot be expressed linguistically. Considering that it is more desirable for research to be communicable, disseminable and reproducible, and as the results of this research are works of intermedia art, their value and impact on the academic and artistic community exists, since, according to the above, the intermedia works produced in this PhD, as recipients, are valid as a means of transmitting intermedia knowledge.

RESEARCH RESULTS: INTERMEDIA WORKS

Of the various works resulting from the reflective practical research, four were chosen for their international recognition as innovative works. As such, these four works are considered to have the greatest potential as a contribution to the evolution of knowledge in the field of intermedia art and design.

In general, these are global interdisciplinary and transdisciplinary works that comprise a concatenation of aesthetic, scientific and technical tasks and processes, forming a [spectrum313] that integrates: the creation of the name of the artistic work; the creation of its graphic identity; the audiovisual documentation of the work; the *web design* of the sites where the work is published; sculptural design; the construction of objects as a design challenge; software design and programming; the design of electronic systems and their implementation; lighting design; sound design and composition; algorithm design; testing; written conceptual theorisation; the description of the works themselves and the processes involved; the translation of literature; the dissemination of the work; the management of material, human and technical resources; among many other tasks that need not be enumerated.

313 Part of the audiovisual documentation that attests to the transdisciplinarity of the works is available on the Internet. This documentation has already been viewed by thousands of Internet users worldwide and is referenced in some of the most important portals on Art, Technology and Design.

Three of these works incorporated, among other means, computer programmes developed exclusively in the context of this research. Thus, before developing a written rationale that explains the process of designing and developing these works, and in order to better understand part of this rationale, the following section is dedicated to presenting the concepts of algorithm and stochastics, which are fundamental to computer programming and computing developed and addressed as means in this research.

ALGORITHM, ITERATION, STOCHASTICS AND COMPUTER

One of the means used in the intermediate fusion achieved in this doctoral thesis was the design and development of original algorithms to be executed by computer. Algorithmic processes that generate artistic forms have a long and venerable tradition, which includes, for example, the composer's score, the architect's plan, or the dance choreographer's notes.

Algorithms originate in mathematics, in the process of solving a problem step by [step]. According to Schmitt (2000), algorithms consist of rules, operations, memory (usually computers), inputs, and outputs. Operations transform the values of memories, inputs, and outputs. The rules define which operations to perform, depending on the conditions in the values of the inputs and memories. Algorithms are fundamentally deterministic, finite, and do not intuit or make random choices. Guedes (2005) describes the algorithm as 'a precise plan to perform a sequence of actions with a well-defined objective'. Cope (2007) says that 'it is a step-by-step recipe for achieving an objective'.

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314 A classic example is the Euclidean algorithm – a process used to find the greatest common denominator of two numbers. The result is the same whether the process is performed by a computer or by a person.

specific objective'[315]. For Wegner (1996), algorithms are metaphorically autistic when they are executed only according to rules and without interaction.

Maresca (2003) considers that there are static entities in the algorithm called objects, which can be of three types: input, output and algorithm. However, randomness can be introduced into an algorithm in various ways. The actions determined by the algorithm are completed by the performer who executes them. The performer of the algorithm therefore gives it variability, being able to interpret it and introduce randomness. According to Maresca, algorithms designed to be executed by a computer are called programmes. In a computer, randomness can be simulated, or the programme can have connections to the outside world that allow randomness to be introduced into the programme itself. The algorithmic systems, programmes, resulting from this research are indeterministic systems because data from the indeterminate actions of the audience as well as stochastic processes were introduced into them simultaneously, so they can be associated with randomness and unpredictability. Randomness is often used to make decisions. Stochastics and randomness, very popular in the world of games of chance, have been repeatedly used as an aesthetic resource, for example in literature, music or the visual arts. The undeniable importance of including these processes, as means of the intermediate synthesis developed in this PhD, is to contribute to the indeterminacy of the works resulting from this research.

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315 Translation by the author from the original: *'An algorithm is a step-by-step recipe for achieving a specific goal.'* (Cope, 2007)

316 We suggest consulting the work 'Towards a Model for Artificial Aesthetics' where Carvalhais (2010) discusses in depth various techniques and concepts related to randomness and pseudo-randomness.

317 It refers to processes that are subject only to the laws of chance. It is related to randomness and probability, subject to the uncertainties of chance. Dependent on circumstances, whether casual, fortuitous or uncertain.

318 There are several ways to generate randomness. For example, when we toss a coin, the probability of the coin landing with the 'heads' side up is the same as the probability of the coin landing with the 'tails' side up, i.e. they are equiprobable. The same happens when we roll a die; each of the six sides has an equal probability of landing face up.

The power of computers has eliminated the tedious work of executing certain algorithms, leaving humans free to focus on the creative part of the work, namely the process that is the algorithm. Computers can execute any process, as long as that process can be described, so they are an excellent means of executing algorithms. Algorithms can be written in any language, but to be executed by computers, they must be expressed in computational language. A computer connected to the appropriate machines can execute instructions to play music, draw, and countless other possibilities.

For Schmitt (2000), a programme, particularly a computer programme, is a dynamic object, which is not the case for other objects such as an image, a sound recording, a film or a sculpture. A programme acts and reacts according to its internal states or in relation to its environment: the programme has an [environment]. This dynamic property, together with the universal malleability of the algorithm, is the reason why the computer is also a means of creation and expression. This dynamism makes this medium radically different from its predecessors such as painting, photography, cinema or video. In fact, with the computer, the artistic work can continue to change while it is being observed, even because it is being observed.

The component of artistic work with computers contains its own abstraction and is thus capable of transforming itself by acting on its own description. Artistic work with computers exists not only as an active form, but also as a language of action, and treating the language of action as a medium makes the programme active and autonomous.

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319 We suggest reading the section 'Algorithm Environment' in Maresca (2003).

According to Schmitt, programming algorithms constitutes the main conceptual specificity of the computer as a means of artistic creation, as opposed to the use of the computer as a means of communication. In the context of the present research, in a way, computer programming itself contributes to the indeterminacy of the process of intermedia fusion, since, in the artistic context, programming is also open to serendipity. In the dimension of algorithmic programming, certain errors can present themselves as unexpected solutions.

The reflective practical research developed in this PhD focused on the creative component of the process that is the algorithm, approaching it as an audiovisual composition technique based simultaneously on rules and stochastics. The design, modelling and execution of algorithms transform their programming into a means of artistic expression, which, among other possibilities, allows expression through the development of principles and methods that support the creation of data mapping systems. The programming of algorithms with digital data allows for a dual conceptual approach: on the one hand, the object with behaviour embedded in time; on the other, the object that contains its own description and representation.

Computer programming in the context of intermedia practice is a means that contributes to the equity between media already discussed earlier in this text. At the end of the 20th century, Ox (1999) refers to the use of the computer as a means of entering the world of interaction between different senses, relating it to the phenomenon of synesthesia: 'information collected by one sense that provokes an experience in another sense'.

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320 Macedo (2002), referring to algorithm programming, considers that often, due to a lack of understanding, when one does not understand, one discovers things... accidents. When things are not understood, one is more apt to explore and understand. He therefore concludes that it is more rewarding to explore than to reach conclusions, more rewarding to imagine/dream than to know, and more exciting to search and explore than to stand still.

through the transfer of this information'[321]. Ox believes that certain programmers develop computer programmes that cause precisely this interaction between sound and image. In fact, computer programming languages are an excellent syntax for integrating intermedia dynamics and reinforcing the equity of the media, because the binary representation of information on different media is the same and can be modelled homogeneously. The binary representation of sound, image, temperature or movement is exactly the same thing: binary data. According to Friedman (2007), 'a world where information and digital computer code flow is beginning to make all media fluid, as digital control has begun to break down the boundaries between different forms of input, transmission and output'[322].

The aim of this research is not to discuss synesthesia, computing, computers, information, or programming, but rather to affirm the equality of the means in intermedia practice: computers, programming, information, algorithms, bits, electricity, human beings, and thought, as means, are as important and valuable as any other phenomenon used as a means in the dynamics of intermediation. In this sense, the following sections present a written rationale that explains the process of conception and elaboration of the works resulting from the reflective practical research developed in this doctoral thesis.

321 Translation by the author from the original: *'One experiences the same phenomenon in synesthesia: Information gathered by one sense creates an experience in another through the transfer of that information*.' (Ox, 1999, p.7)

322 Translation by the author from the original: *'a world in which digital computer code and information flows would begin to render all media fluid as digital control began to break down boundaries between separate forms of input, transmission, and output*.' (Friedman, 2007, p. 10)

COLMUS AND SOLU CORRESPONDENCE PROPOSAL

The works ColMus and SoLu result from the need to model and integrate sound and visual materials as a whole, that is, to homogenise the processes of audiovisual conception and production in an intermedia, hybrid process, simultaneously demonstrating a theoretical proposal for correspondence between light and sound. This proposal attempts to answer the question: what is the possible relationship between a sound spectrum and a light spectrum? Does a low sound correspond to a chromatic sensation323 of 'blue', 'red' or any other colour?

After developing several experiments and works that synchronise concordant or discordant sound and visual events, it was found that this type of work can be classified in the field of so-called synaesthetic, synesthetic or multisensory art. Reading Cretien Van Campen's work 'Hiden Sense' (Campen, 2010), which aimed to clarify and understand the state of the art in the field of synesthesia, was fundamental in the development of these works, making three aspects very clear: 1. the synesthetic experience is personal and individual; 2. human beings in their first months of life do not 'distinguish' the senses, only beginning to modulate the senses from a few months of age; 3. one of the most common types of synesthesia is the experience of chromatic sensation caused by the experience of sound sensation.

Studies on the various manifestations of synesthesia point precisely to a psychological, mental, and individual origin, making it very complex to create a matrix or pattern of correspondence between sensory stimuli from one of the five senses and the respective sensory responses in another of those same five senses. Given the complexity and mystery of the human mind, we chose to develop an approach

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323 The chromatic sensations we experience result from the emission or reflection of light. The colour of an object depends on the spectral composition of the incident light, the spectral reflectance or transmittance of the material of which the object is made, and the spectral response of the observer.

scientific approach of a physical nature that would allow us to substantiate a proposal for a correspondence between sound and light.

In order to simplify and objectify the study, in the initial phase, the focus was solely on the relationship between one of the elements of visual language, colour, and sound. This study resulted in a new proposal for a correspondence between the visible and audible spectra for human beings, which was demonstrated and materialised in two intermedia works that integrate, among other means, two hyperinstruments, resulting from the process of reflective practical research developed in this PhD.

Both visual and auditory perception depend on physical phenomena of energy transport, electromagnetic and mechanical respectively. These phenomena are studied and described by scientific knowledge of physics with a high level of 'objectivity' and quantification. It was in fact this level of 'objectivity' that served as the basis and 'trigger' for the new correspondence proposal. Basically, each audible frequency was matched to a visible wavelength, i.e. a direct correspondence was established between the audible and visible spectra. Before publishing and substantiating this proposal, a survey of previous proposals was carried out, duly documented and published.

In summary, it was concluded that existing proposals related colour to music in a very unbalanced and reductive way. While colours from almost all wavelengths of the visible spectrum are used, only 7 musical 'notes' from the tempered diatonic scale or 12 musical 'notes' from the tempered chromatic scale are used, which are themselves a cultural convention. The dissatisfaction with these proposals boiled down to the following: the zero C, from the leftmost octave on a piano keyboard, is

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324 Tod Machover (Machover 1992) proposes the term hyperinstrument to define tools resulting from technological research in the field of arts that transcend the traditional limits of amplifying human gestures. Machover considered them musical instruments of the future that, aiming at increased expressiveness, will redefine musical expression itself.

No, it is much more 'serious' than C8, further to the right on the same keyboard, but according to previous proposals, listed in Collopy's table (2004) shown in Figure 2, all Cs would correspond to the same colour because the mapping was limited to only one octave. In addition to this constraint, it was already noted during the production phase of the second hyper-instrument, SoLu, that the colours chosen for the correspondences proposed over the last three centuries were mostly colours aligned according to their order in the visible spectrum, each of which corresponds to a specific wavelength. However, given the spectral composition of sound, a series of frequencies — harmonics — are associated with the corresponding musical note, depending on the specific instrument that produces them. This fact led to the use of so-called pure tones, sinusoidal waves, processed synthetically, in the demonstration of the proposed correspondence, so that, theoretically, the harmonics would be eliminated.

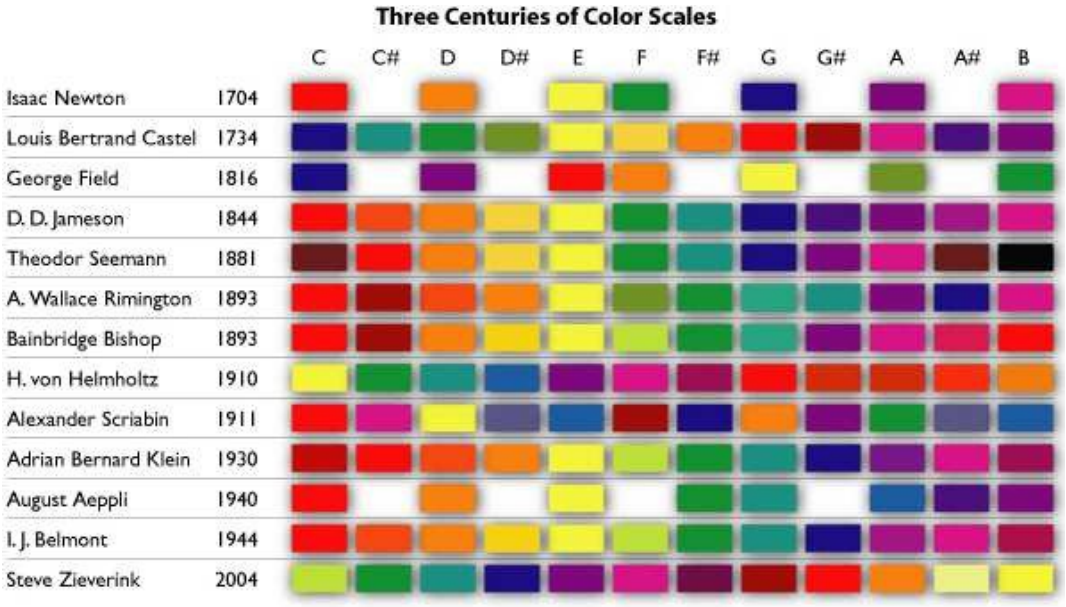

Figure 2. Three Centuries of Colour Scales. Fred Collopy 2004.

Following the analysis of previous correspondence proposals, it was decided to produce a new proposal based on the physical magnitudes of sound and light phenomena, without considering the randomness and diversity

of the correspondences found or imagined by human beings who experience the psychological phenomenon of synesthesia. Initially, intuition seemed to suggest a correspondence in which low sounds would correspond to bluer colours and high sounds to redder colours. But this correspondence was totally arbitrary.

The proposed correspondence based on the physical magnitudes of sound and light was exactly the opposite of the intuited correspondence, i.e., low-pitched sounds with longer wavelengths correspond to reds with longer wavelengths, and high-pitched sounds with shorter wavelengths correspond to blues with shorter wavelengths. This proposed correspondence, as well as the hyperinstruments that make up the intermedia works ColMus and SoLu, will be described in more detail in the following sections.

PROPOSED CORRESPONDENCE

Light and sound phenomena are similar in many ways. Both are phenomena of energy transport studied simultaneously by physics. Considering the wave theory of light, both propagate through waves, longitudinal mechanical waves in the case of sound and transverse electromagnetic waves in the case of light. Both phenomena require space-time between their emission and reception.

The physical characteristics of these phenomena also differ: electromagnetic waves such as light can propagate in a vacuum, but sound waves require a material medium to propagate. In air, light propagates at a speed of 300,000,000 m/s and sound at a speed of 344 m/s. Electromagnetic waves perceptible to the human eye oscillate between 430 THz and 750 THz with wavelengths between

740 and 380 nm, while sound waves perceptible to the human ear oscillate approximately between 20 Hz and 20 KHz with wavelengths between 17.15 and 0.0172 m. Despite the enormous differences in magnitude and speed, both electromagnetic waves and sound waves can be represented by wavelength and frequency.

Almost all light and almost all sounds are composed of a complex mixture of vibrations of different frequencies, i.e., they have a spectral composition. Light is almost entirely polychromatic, meaning it can be described by a spectrum with several different frequencies. The same is true of the sounds we hear, which almost always result from a mixture of several frequencies. However, there are exceptions: monochromatic light, described by only one frequency or wavelength, and so-called pure tones, which are also composed of a single frequency. Both monochromatic light and pure tones are uncommon in nature but can be synthesised. Examples include coherent light emitted by laser devices and sound produced by frequency synthesizers.

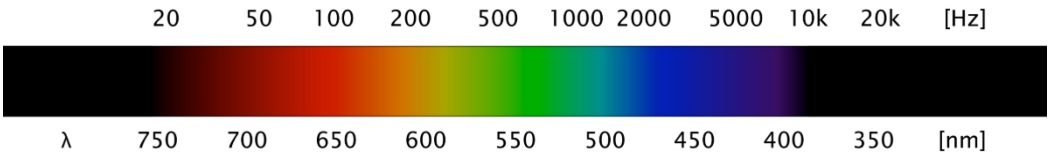

Figure 3. Proposed Correspondence. André Rangel 2009.

The theoretical proposal for correspondence between light and sound developed in this doctoral thesis basically aims to match the lowest visible electromagnetic frequency with the lowest audible sound frequency, and the highest visible electromagnetic frequency with the highest audible sound frequency. In a first approach, we attempted linear mapping, commonly known as scalar mapping, of a series of numbers (values of the frequencies of electromagnetic waves in the visible spectrum) onto another series of numbers (the values

of sound wave frequencies in the audible spectrum). This mapping did not work because our auditory perception of sound frequencies is exponential[325]. This mapping resulted in the following: for a large part of the audible spectrum in the lower frequency range — low-pitched sounds — the variation in chromatic sensation was minimal; and in a small part of the audible spectrum in the higher frequency range — high-pitched sounds — the variation in chromatic sensation was very large.

In order to create a more 'coherent' correspondence, a mathematical model was sought that would allow the exponential spacing of the intervals between the frequencies to which the basilar membrane is sensitive to be converted into linear spacing of the wavelengths of the visible electromagnetic spectrum. Two experienced mathematicians were contacted and, after being presented with the challenge, they concluded that there was no mathematical function that could solve it with complete accuracy. One of them, Professor António Leite[326], suggested finding a mathematical model that came closest to the desired result. To this end, possible models that could be adapted were researched and the following model was found: $(n= 12*(\log(f/440)/\log(2)) + 69)^{327}$, which allows the fundamental frequency of each of the notes in a piano's tessitura, exponential progression, to be converted to MIDI[328] values, linear progression. With the support of pianist and architect Anne-Kathrin Siegel, the previous model was adapted to the following: $(n = 700 — (12*(\log(f/220)/\log(2))+36)*3.44827586207)$, which allowed the frequencies of an exponential scale to be converted into wavelengths of a linear scale — in this specific case, wavelengths of electromagnetic vibrations within the visible spectrum.

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325 The auditory perception of frequencies is exponential because the basilar membrane, inside the cochlea in the inner ear, has an exponential gradation of rigidity. We suggest consulting the work ‘Experiments in Hearing’ by

326 António Leite is co-author of several mathematics textbooks: http://www.culturminho.pt/Livro/Autor/_António_Leite

327 This model is published, for example, at: http://www.phys.unsw.edu.au/jw/notes.html

328 MIDI stands for Musical Instrument Digital Interface. For more information, visit http://en.wikipedia.org/wiki/MIDI

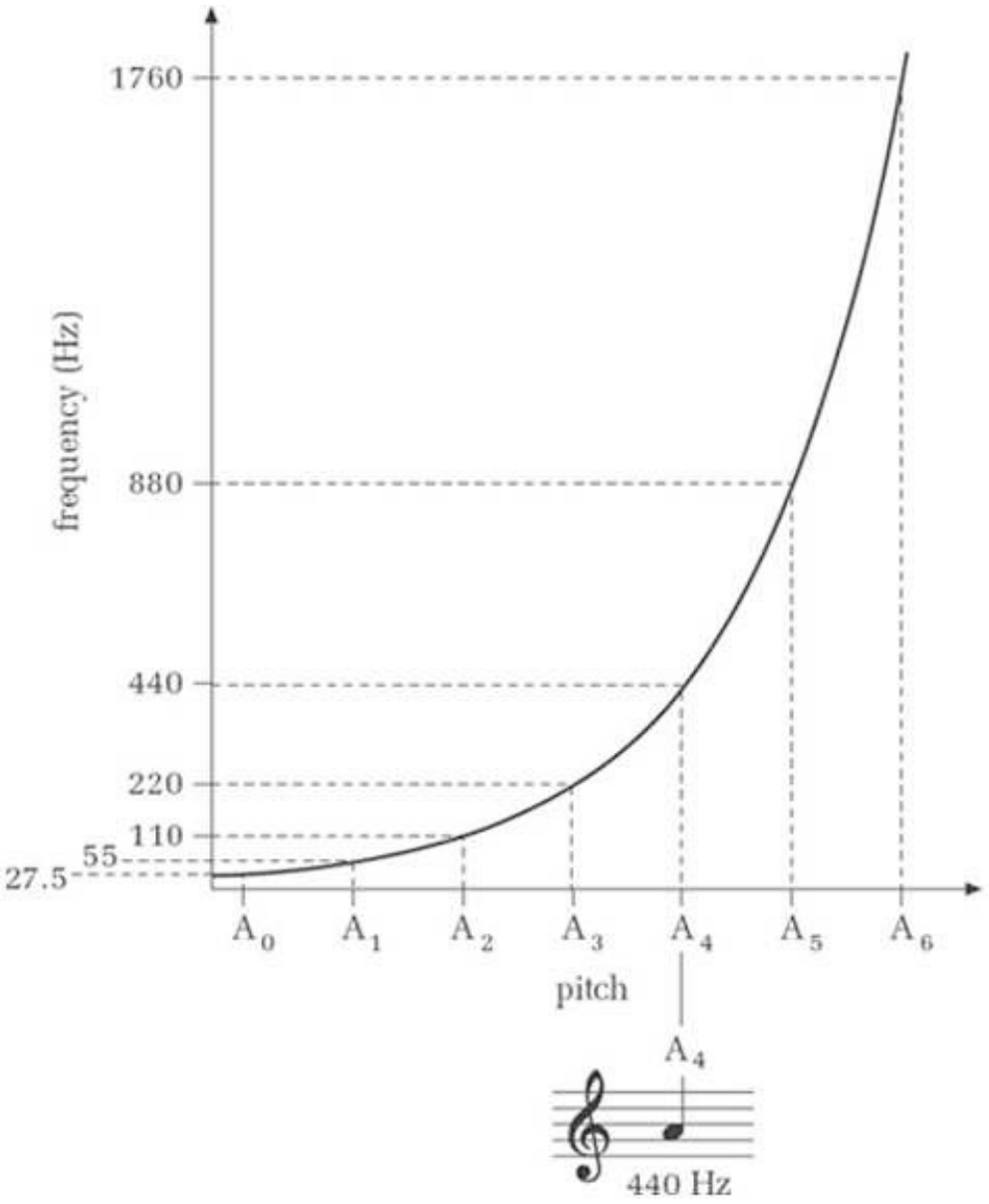

Figure 4. Exponential relationship between musical pitches and frequencies. Isle of Wight Council 2013.

During this research, it was surprising that the sound spectrum is almost always represented in the frequency domain and the visible spectrum in the wavelength domain, given that frequency and wavelength are inversely proportional quantities. This fact presents a certain inconsistency in the scientific approach to measuring light and sound phenomena. The question then arises: if light and sound are,

as mentioned above, phenomena of energy transport, electromagnetic and mechanical respectively. If both can be studied as wave phenomena, and as such their wavelengths and frequencies measured. But by convention, light phenomena, which are perceptible to humans, are measured in nanometres — relative to electromagnetic wavelengths, while sound phenomena are measured in hertz — relative to the frequency of sound waves. The question was therefore raised as to why the two phenomena in question are not measured using the same model and the same unit of measurement. The reason for using different units of measurement was considered, and it was concluded that there may have been some practical advantage, in terms of ease of calculation, with one or the other measurement respectively, or simply that these phenomena had been studied in a hermetic and separate manner for a long time. It is not the aim of this research to clarify the reason for this 'separation', but the fact was noted and recorded.

After adapting the conversion model presented in this section, we moved on to building a system that would allow us to demonstrate it. The process of building this system will be described in detail in the following section.

NANOMETRES FOR RGB

After successfully adapting the mathematical model described in the previous section, it became necessary to demonstrate it by using it in an intermedia work of art, specifically in an audiovisual hyperinstrument. At first glance, the most obvious way to demonstrate the theoretical correspondence would be to use an oscillator to generate a 'pure' sound tone and use a 'coherent' light source. Coherent light sources — lasers — available for civilian use do not allow for variation in the wavelength of the emitted electromagnetic vibration, so their use would make demonstration impossible.

of the electromagnetic vibration emitted, so their use would make demonstration impossible.

Given this impossibility, it was decided to use a light source consisting of an additive colour synthesis system with three components: red, green and blue, commonly referred to as the RGB colour system or colour space. This colour system, in addition to being the standard for most current display devices, from monitors to projection systems, made the demonstration more financially feasible, given the availability of [devices] that use this system.

However, RGB colour spaces cannot produce all the visible electromagnetic vibrations — colours — present in the [visible] electromagnetic spectrum. In addition to this impossibility, there is also the fact that all chromatic sensation depends on the spectral composition of the light incident on the object or surface being observed, on the spectral reflectance or transmittance of that same object or surface, and also on the spectral response of the observer. Thus, given the technological and physical constraints just outlined, which were taken as a starting point, it was accepted that the demonstration of the proposed correspondence would have to be an approximation.

The system that was decided to be designed should therefore convert the number of Hz of a given audible frequency into three RGB coordinates that would produce a chromatic sensation approximating the visible electromagnetic vibration of wavelength determined by the mathematical formula already presented in the previous section. Different models and formulas for converting wavelengths (in nanometres) to RGB coordinates were investigated. Given the diversity of available models and

329 The RGB system is used in television screens, computer monitors, video projectors and LED screens.

330 More information about the limitations of the RGB system can be found at: http://www.pfk.ff.vu.lt/cie/1931CIE_explanation.htm Image: http://www.pfk.ff.vu.lt/cie/images/cie_full2.png

In order for the choice to be supervised by an expert, photometry specialist Stefan Grünsteidl was contacted. After being presented with the challenge, Grünsteidl agreed to collaborate on the solution for converting nanometres into RGB coordinates. His efforts led to the conversion of wavelengths, which constitute the visible spectrum, to the three-dimensional colour space XYZ CIE. Grünsteidl collaborated in this research by providing a conversion table from nanometres to XYZ CIE colour space, with a resolution of five nanometres.

In order to achieve greater fluidity and continuity, a computer programme was developed, for which an algorithm was designed capable of calculating the interpolation of the values in the CIE table provided by Grünsteidl. In this way, it was possible to obtain coordinates in the CIE XYZ colour space corresponding to any value of an electromagnetic wavelength in the visible spectrum.

331 Master Stefan Grünsteidl from the National Centre for Laser Applications at the University of Galway in Ireland, who was in Portugal at the time developing a patent at the company 'Multiwave Photonics, SA', which specialises in lasers and fibre optics.

332 CIE - *Commission Internationale de L'Eclairage* - International Commission on Illumination. A scientific, technical and cultural organisation which, among other activities, develops standards and metrology procedures in the fields of light and lighting. http://www.cie.co.at

333 The conversion table can be found in the appendices to this thesis and is available at: http://cvrl.ucl.ac.uk/database/data/cmfs/ciexyz64.csv

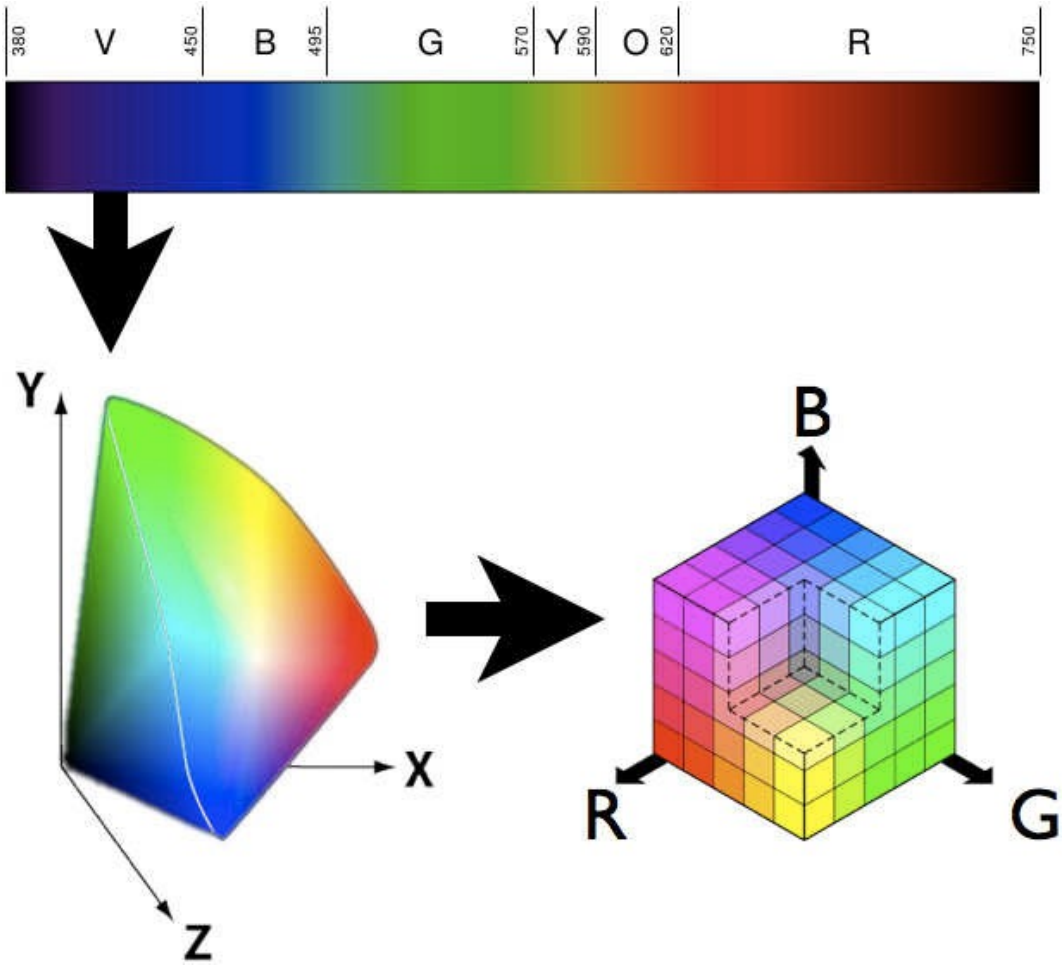

Figure 5. Method used to convert a visible wavelength to the RGB colour space, which involves an intermediate conversion to the CIE XYZ colour space. André Rangel 2009.

The conversion from the CIE XYZ colour space to the RGB colour space was achieved by integrating another algorithm into the computer programme, designed exclusively for this purpose. This algorithm implements a neutral programming function, published on the EasyRGB[334] website, which provides specialised information on colour and colour technology-related services. This website is a reference resource on colour, colour science, programming techniques and compiles a series of links dedicated to the physics, psychology, physiology and technology of colour.

334 The neutral programming function can be found in the appendices to this thesis and is available at: http://www.easyrgb.com/index.php?X=MATH&H=01#text1

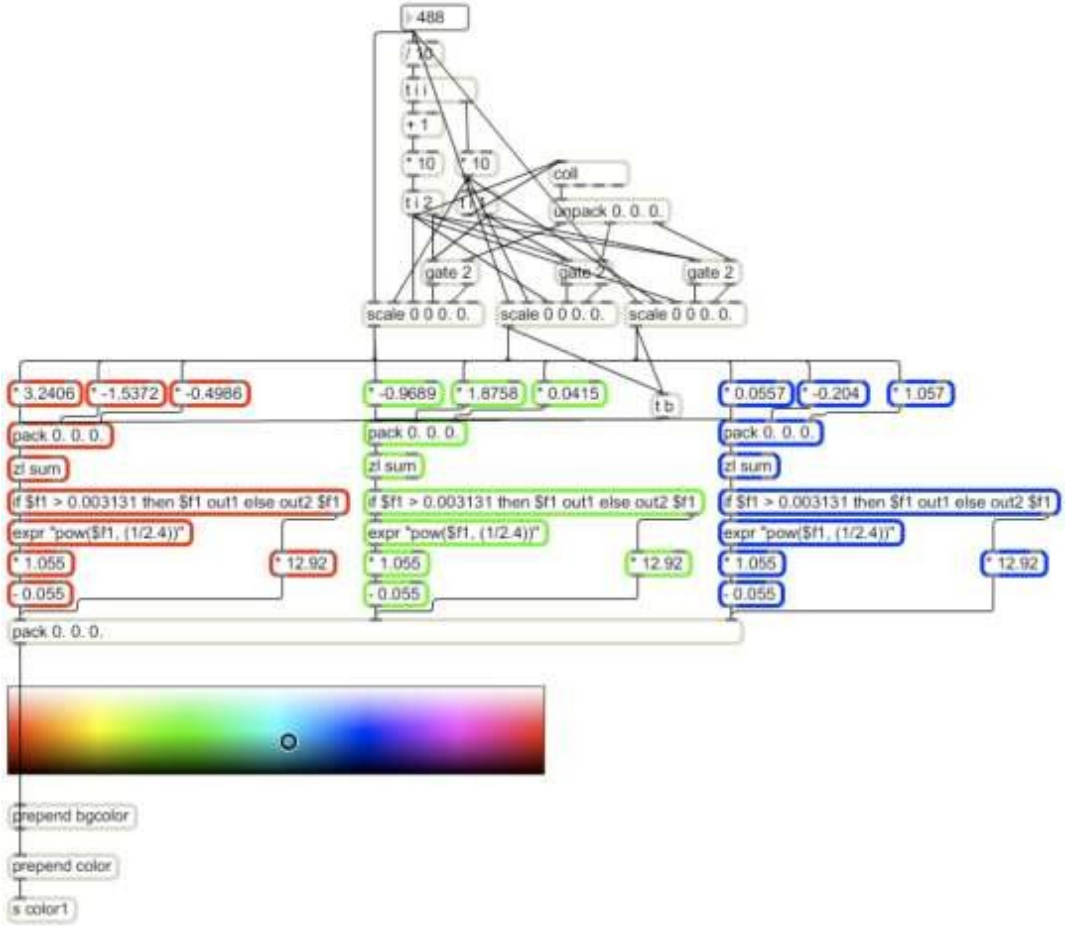

Figure 6. Implementation of the algorithm in the MAX Msp programming environment for converting nanometres to RGB. André Rangel 2010.

In short, despite it being physically and technically impossible to produce, with RGB systems, all the electromagnetic vibrations that make up the visible electromagnetic spectrum, a conversion system was implemented, from wavelengths to the three RGB coordinates, which produces the chromatic sensations that most closely resemble those caused by the electromagnetic vibrations present in the visible electromagnetic spectrum. This system was integrated into the computer application that was designed and programmed and, in conjunction with the mathematical model described in the previous section, allowed a given audible sound frequency to be converted in real time into a chromatic sensation produced by an RGB system.

COLMUS



Figure 7. Presentation of the work ColMus at the Portuguese Catholic University. André Rangel 2009. Photograph by Jorge Rêgo.

As mentioned above, the hyperinstrument that forms part of the ColMus[335] work stems from the need to demonstrate the theoretical proposal of correspondence between sound and light described in the previous sections. The aim was to go beyond a simple demonstration and immediately integrate the proposal into an interactive intermedia work of art. Taking into account another objective, to motivate and empower the viewer, he designed

335 http://3kta.net/3colmus.php

and produced a new medium, a hyperinstrument, which would facilitate audiovisual expression for anyone, without requiring learning, verbal language or training. In parallel with these two objectives, demonstrating the theoretical proposal of correspondence and producing a means of audiovisual expression, the design of this hyperinstrument also aimed to integrate the response to a work proposal from the curricular unit called 'Algorithmic Composition', from the doctoral programme in Musical Informatics at the Portuguese Catholic University.



Figure 8. Hyperinstrument. André Rangel 2009. Photograph by Jorge Rêgo.

The process of materialising the hyperinstrument in ColMus was developed simultaneously through the fusion of research in three main areas: software design, hardware design, and the meta-composition of possible audiovisual results. This approach confirms, in a way, Alan Kay's famous quote: 'People who are seriously interested in

software developers should make their own hardware336' (Kay, 1982). The interest of this research in the development of *hardware* as a tangible, structural and physical component of the work arises as a continuation of the artistic production tradition of researcher André Rangel, who since 2001 has been producing work in the field of Digital Art, always exploring the incorporation of the audience. *Hardware* is precisely the technological boundary that allows the participation of the bodies of the people who make up the participating audience.

Another characteristic of ColMus is that its audio-visual hyperinstrument exists in the work as a means of meta-conception. In the context of this research, meta-design should be understood as the design of tools, parameters and operating conditions that allow users to make the final decisions, transferring the advantages of design and use to the end user: the audience. The sound response in ColMus was meta-designed according to musical metrics, to allow part of the research developed in the production of this hyperinstrument to be considered as an element for evaluation in the aforementioned 'Algorithmic Composition' course unit.

Since music is recognised as an almost [universal] cultural phenomenon, it was decided to use musical vocabulary to facilitate understanding (even if unconscious) and enjoyment of the work by a larger and more heterogeneous group of people. In this sense, in ColMus, the correspondence proposal was adjusted so that only the fundamental frequencies of the notes within the range of a piano were considered. As it is an instrument frequently used in the process of musical composition and because it is one of the most common instruments in an orchestra, the piano was chosen as the reference instrument.

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336 Translation by the author from the original: *'People who are really serious about software should make their own* hardware' (Kay, 1982). Alan Kay, a computer scientist, uttered this phrase during a presentation at the 'Creative Think' Seminar on 20 July 1982. Source: http://folklore.org/StoryView.py?project=Macintosh&story=Creative_Think.txt

337 M. Higgins (Higgins, 2012) investigates the universality of music from the perspectives of philosophy, psychology, musicology, linguistics, and anthropology.

Among classical instruments, the one that produces the widest spectrum of musical pitches, the piano was chosen as a reference in this first demonstration. Figure 9 graphically illustrates the correspondence used in this hyperinstrument.

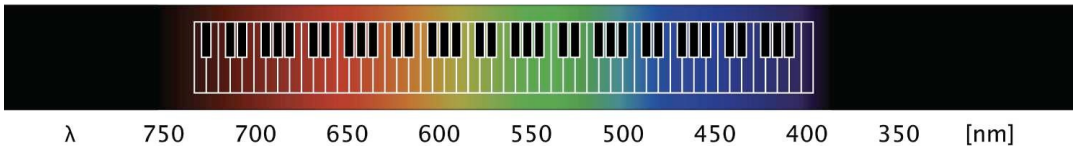

Figure 9. Proposed correspondence adjusted in ColMus. André Rangel 2009.

Thus, the name of the work ColMus is a hybrid term, resulting from the contraction of the words Colour and Music, affirming the hybrid nature of the work and its process of materialisation, which results from the fusion of various material, biological and conceptual means. The following section describes in more detail the process of algorithmic meta-composition developed for the hyperinstrument that integrates this work.

ALGORITHMIC COMPOSITION

The audiovisual composition generated in ColMus by the hyperinstrument, while it is being operated by users, is calculated in real time by an original algorithm. The musical dimension of this composition, more specifically, the meta-composition, results from a meta-conception process involving, upstream, the researcher, and, downstream, the users who interact with the generative algorithmic system that integrates the hyperinstrument. These interventions and interactions form the intermedia work ColMus in a process of media fusion.

The genesis of the design of this generative algorithmic composition system[338] resulted from observing the hands of a pianist while playing their instrument. From this observation, two recurring characteristics were noted. The first is that pianists often play a chord with one hand and simultaneously perform a kind of solo with the other hand; the second is that the notes played by the solo hand often belong to the chord played by the other hand. These two observations led to the system being programmed to calculate combinations of three musical notes that sound like chords and to select notes that sound like a solo.

Another important factor in the meta-design of the composition was the creation of a very simple interface that does not require any kind of literacy or learning. In the initial phase of the research, the point of contact between this interface and the user consisted solely of a rotary knob — a potentiometer[339] — which allowed the user to control the melodic line of the composition calculated in real time at the moment of interaction. At a more advanced stage of the research, the ColMus hyperinstrument incorporated a second potentiometer to control the speed — bpm — of the musical composition. Thus, the hyperinstrument remained simple to use, as users only had to turn the two potentiometers to interact with the work.

The ideas that led to the meta-conception of musical composition, to be calculated by ColMus, are simple: the melody would have to be generated in real time, meaning that there could be no musical phrases or any pre-established or programmed sequences of notes; the rhythmic pattern would also have to be generated in real time.

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338 According to Nierhaus (2010), algorithmic composition is composition that uses formalizable methods. This author describes algo-rhythmic composition as a formalizable abstract procedure, applicable to the generation of musical structure. Dobrian (2008) considers that repeating an action or counting at a certain rhythm, or reading a list of instructions, are basic human activities that can be easily programmed. These types of actions are useful foundations for programming composition algorithms. Understanding the system that allows humans to perform such actions makes it possible to systematise processes to be performed by a computer.

339 Electronic device that allows electrical resistance to be regulated.

340 Be*ats Per Minute*. We suggest consulting the following web page: http://en.wikipedia.org/wiki/Tempo

generated/calculated in real time, and there could be no pre-established rhythmic patterns or sequences; finally, users would have to feel in control of the composition. Of the various methodologies for computer-generated algorithmic composition, ColMus used two distinct strategies simultaneously, namely: rule-based strategies and stochastic strategies.

We will now describe how musical composition is generated in real time in ColMus. One of the rules of this composition is the rhythmic variation generated in real time during the performance of the hyperinstrument. To this end, a quaternary bar was considered and an algorithm was designed that pseudo-randomly determines, at the beginning of each bar, the number of rhythmic units — sixteenth notes — that will exist in that bar. The number of rhythmic units varies between one and sixteen in each bar. The same algorithm arranges the rhythmic units in a 'pseudo-random' manner in the sixteen possible positions in the bar, immediately before it is played. This means that each bar has a different number of rhythmic units, and these are always distributed differently in the sixteen positions of the bar. Stochastically, only two rhythmic units may be played in one bar and sixteen in the next. This gives the musical composition rhythmic contrast, which according to Roy Bennet (Bennet 1982) is one of the two basic ingredients of musical design and form. According to Bennet, the other ingredient is repetition, which in ColMus is ensured by the triggering of a melodic event at the beginning of each bar. The algorithm that calculates the rhythmic sequence of melodic events is executed simultaneously in two instances. Each of these instances affects, respectively, the triggering of chords and solo notes. Thus, the quantity and positioning of chord detonations and solo notes in the bar is always variable, reinforcing variation and unpredictability: in some bars, more chords are played than solo notes, and in other bars, the opposite occurs. To

variability generated by the stochastic processes described, added to the user's intervention, which determines the speed of execution of the bars in real time.

For the melodic component in ColMus, three musical chords were chosen that constitute a perfect cadence: C minor chord, F minor chord, and G major chord. Each o f these chords is composed of a different combination of three of the following musical notes: C, D, E flat, F, G, A flat, and B. These are the musical pitches used throughout the melodic component of the work. This component is also controlled in real time by users, for which purpose the algorithm that generates the composition integrates an indexed list with all the first notes that form the three chords used. These notes are C, F, and G. The first element of this list is considered to be a zero C, 'low', with a fundamental frequency of 32.70 Hz, and the last element of this list is a C eight, 'higher', with a fundamental frequency of 4,186.01 Hz. In other words, the list consists of 22 musical notes corresponding to all C, F and G notes whose fundamental frequency varies between 32.70 Hz and 4,186.01 KHz.

Using a potentiometer, the user/performer chooses one of the 22 indexes from the aforementioned list. The algorithm, created through a stochastic process, causes a 'random' transposition of that position at each rhythmic event, executing one of three possibilities: decreasing, maintaining or increasing the *index* number. For example, when the user turns the potentiometer to the position that determines the output of the 13th element in the list, corresponding to a C (523.25116 Hz), as with each rhythmic event, the algorithm determines a transposition, as described in the previous period, the note that is actually chosen at each rhythmic event can be: G (391.995422 Hz) — immediately preceding index, 15th element in the list; C itself (523.25116 Hz) — 16th element in the list; or F (698.456482 Hz) — immediately following element in the list, 17th element.

from the list. The note resulting from the user's choice — potentiometer position — associated with the stochastic process just described, will be the note that determines the chord to be played.



Figure 10. Adjusted correspondence proposal in ColMus. André Rangel 2009.

Even before the chord is played, three more random transpositions occur for each of the three notes in the chord. The stochastic process that is applied to each of the notes in the chord is the random determination of one of three transpositions: transposition to an octave below, no transposition, or transposition to an octave above. The introduction of the stochastic processes just described is an aesthetic decision that aims to introduce variability into the control introduced by users. In summary, for each of the 22 positions of the potentiometer, there are 3 possible chords, each of the 3 notes that make up each of these chords can be transposed to one of 3 octaves, that is, for

each position of the potentiometer chosen by the user can result in 81 orchestrations/inversions of these three chords.

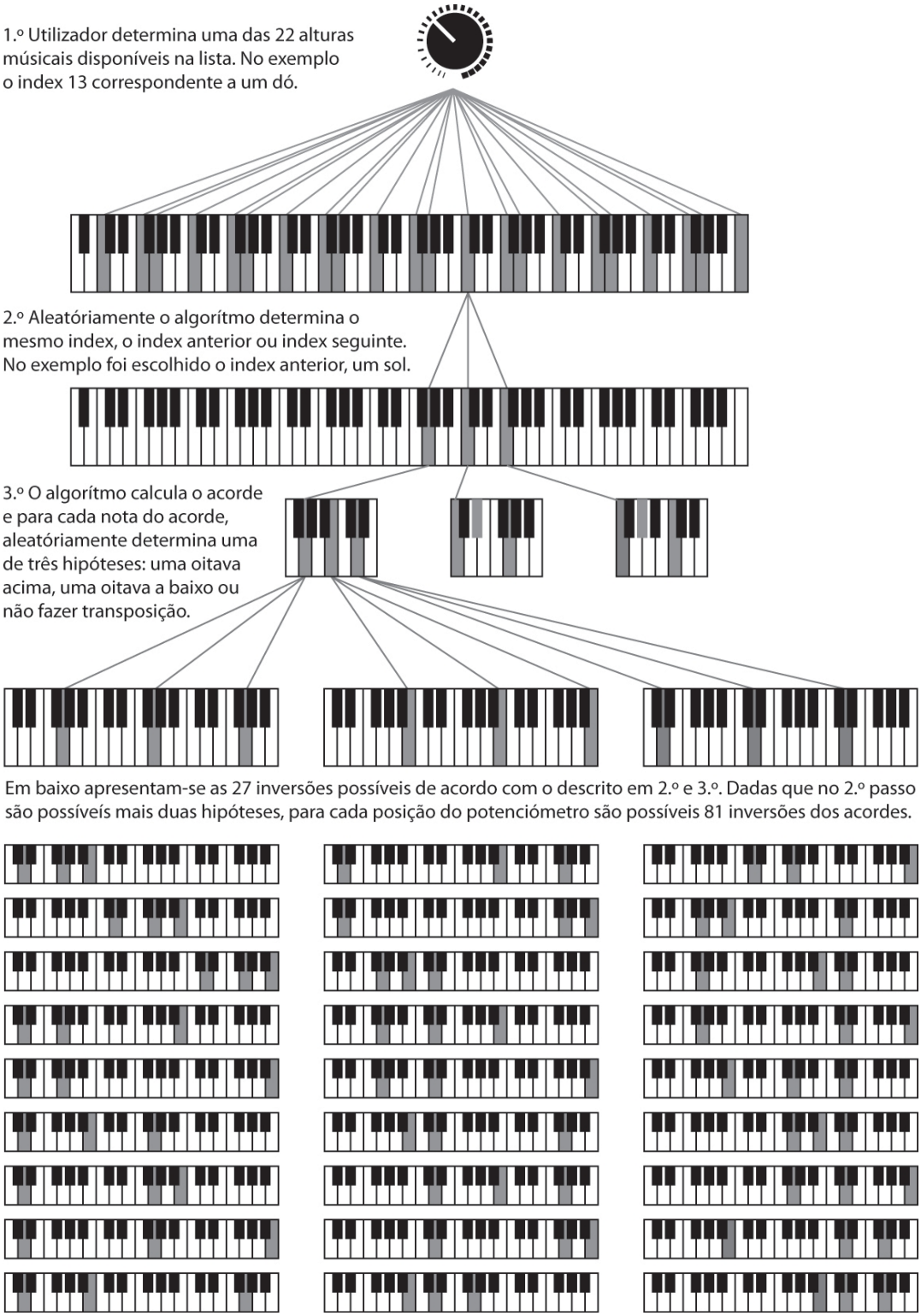

Figure 11. Diagram illustrating 27 of the 81 inversions of 3 chords possible for a single potentiometer position. André Rangel 2010.

Each note of the chord and solo corresponds to a visual event synthesised in real time: a two-dimensional circular crown drawn by instructions sent directly to a computer's Graphics Processing Unit (GPU) in OpenGL language. The colour, area and horizontal positioning of each circular crown are determined by the fundamental frequency of the corresponding note, according to the correspondence proposed in this research. To accentuate the synchronism and fusion of sound and visual events, the scale of these circular crowns is determined by the amplitude envelope of the sound triggered by the corresponding musical note.

INTERFACE

The design and production of the interface in ColMus aimed to simplify user interaction as much as possible. Therefore, from the outset of this research, we sought to banish any possibility of interaction based on the use of conventional interfaces — musical instruments or computers, namely keyboards or mice. In the quest for simplicity of interaction, all interfaces using keys, letters, numbers or any other conventional symbols were excluded, and so an exclusive interface was developed for ColMus.

Potentiometers

As described in the previous section of this text, in the initial phase of the research process for the design of the hyperinstrument in ColMus, con-

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341 OpenGL is a language that is transversal to all the most important and recognised operating systems for computer-aided design. For more information, see: http://www.opengl.org/

342 For a better understanding of the result of the audiovisual meta-composition in ColMus, we suggest viewing and listening to the following document: http://www.youtube.com/watch?v=JBtl5XLN_KI

343 Bongers (2006) considers the interface to be a device or group of devices that facilitates a bidirectional interaction process.

It was decided to use only one variable for input into the system[344]. At this stage of the research, it was considered that the hyperinstrument should have only one controller (a rotary knob or a sensor). For mechanical reasons that allowed the hyperinstrument some 'autonomy', as will be explained below, it was decided that the interface would be controlled by a linear rotary potentiometer [345]. When a user turns a rotary potentiometer to a certain position, it remains in that position even if the user lets go of it. This feature, which could be considered a constraint in other situations, does not apply when using, for example, infrared proximity sensors. The fact that the potentiometer can remain in a specific position supported its selection as the ideal controller for the hyperinstrument.

In addition to its technical suitability, the rotary potentiometer also presented other characteristics, with more charisma, patina, and charm, as it is one of the most widely used controllers in the history of electrical and electronic devices, from televisions to radios to light *dimmers*. A potentiometer is basically a mechanical device that offers variable resistance to the passage of electric current, allowing the voltage to be varied. Through a microcontroller — Arduino, digitalised

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344 Bongers considers that in an interactive or reactive system such as a musical instrument, user control is exercised at the input or inputs of the system: 'An interaction-'loop' may start when the user wants to activate the system. The system is controlled by a user through its inputs, it processes the information, and displays a result. […]The human perceives the information from the system, processes it and controls again' (Bongers, 2000, p. 44).

345 The choice of potentiometer resulted from an analysis of the characteristics of various potentiometers listed by the manufacturer Piher. The list used in this analysis can be found at: http://www.piher-nacesa.com/pdf/controlsv01.pdf

346 Basically, an infrared proximity sensor consists of an infrared (IR) emitting diode, a sensitive detector and a signal processing circuit. Any object placed in front of the IR beam acts as a reflector. The closer an object is to the sensor, the shorter the time interval between the moment the light is emitted and its reception by the detector. The variation in the distance of an object from the sensor is converted into a variation in electrical voltage that can be measured or digitised to be read by a computer programme, for example.

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An IV proximity sensor, calibrated to measure distances between 20 cm and 150 cm, by default when there is no object within this 'field' reads the maximum distance. Unlike a potentiometer that can remain in a certain position, in an IV sensor if we place an object 40 cm away and suddenly remove it, the sensor reading immediately returns to the maximum distance.

Detailed technical information about the IV sensor: https://www.sparkfun.com/datasheets/Sensors/Infrared/gp2y0a02yk_e.pdf

347 For information on the semantics of materials, see the section 'Reflective practice, doing and materials'.

348 The potentiometer has three pins. Electrical current flows through its central pin, with the voltage regulated by resistance that is mechanically controlled by a rod that rotates on its own axis. When the rod is turned fully to one side, 0 volts flow to the pin; when the rod is turned fully to the opposite side, 5 volts flow to the pin.

349 Information on the technical specifications of this microcontroller can be found at: http://arduino.cc/en/Main/ArduinoBoardUno

These voltage variations were used as variable data in the algorithm described in the previous section.



Figure 12. Potentiometer shafts coated with fluorescent film to increase visibility in dark environments. André Rangel 2010.

At a more advanced stage of research into the design of the algorithm that generates musical composition in real time, as mentioned above, it was decided to give users greater control, allowing them to control both the melodic line of the composition and its rhythmic speed simultaneously using two potentiometers (instead of just one). The two potentiometers were mounted on the metal rim as shown in figure x. Given that each potentiometer has three pins[350], six cables would be needed to carry electrical current to and from the microcontroller, with one cable for power supply, another for individual voltage reading and a third for ground connection for each potentiometer. As the two power pins can be connected to a single cable, the same applies to the two connection pins.

350 Each potentiometer has three pins, but only one of these pins is used to measure the voltage variation, while the other two pins are used for power supply and ground connection, respectively.

ground, only four cables were needed in total. For aesthetic reasons and visual ‘cleanliness’, it was decided to connect these two pairs of cables in a place that was not visible, so it was decided to do so inside the wooden box that forms part of the hyperinstrument, specifically inside the connector that will be described below. This avoided having to use '*freestyle* electronics' in the area where the potentiometers are located, which is precisely the most visible area, as it is where users look to position their hands before operating the hyperinstrument. Another reason for moving the connection from 6 to 4 cables inside the box was the fact that a very thin 'flat cable' was chosen to carry electrical current between the potentiometers and the microcontroller, which was glued to the inside of the metal arch. Any connection or intervention in the cable would be very evident, destroying its material semantics. Furthermore, it was intentional to keep this cable as discreet as possible.

351 The term '*freestyle* electronics' refers to the design and assembly of electronic circuits without the use of PCBs (Printed Circuit Boards). I came across this term during a Micro Robotics Workshop led by Ralph Schreiber and curated by André Rangel.

352 'Flat cable' or FFC - Flat Flexible Cable. A flat flexible cable with a series of electrical conductors inside. It is commonly used in electronic assemblies with a high density of components, such as laptops or mobile phones.

353 The semantics of materials was discussed earlier in the section Reflective practice, Doing and materials.



Figure 13. Details of the interior of the metal arch, where freestyle electronics were avoided to ensure visual 'cleanliness'. André Rangel 2010.

Given that the sculptural component of the hyperinstrument had to be removable and divisible into two parts (iron arch and wooden box), the communication, which is established by cable between the potentiometers (on the iron arch) and the microcontroller (in the wooden box), had to be interrupted by a connection that could be easily disconnected and securely reconnected. To ensure the robustness of this connection, and anticipating that the hyperinstrument would have to be assembled and disassembled several times, research was conducted into the most effective type of connector mechanism for this purpose. Given that space was also needed to join four cables in pairs, it was decided to find a connector that could accommodate this connection (see image 14).

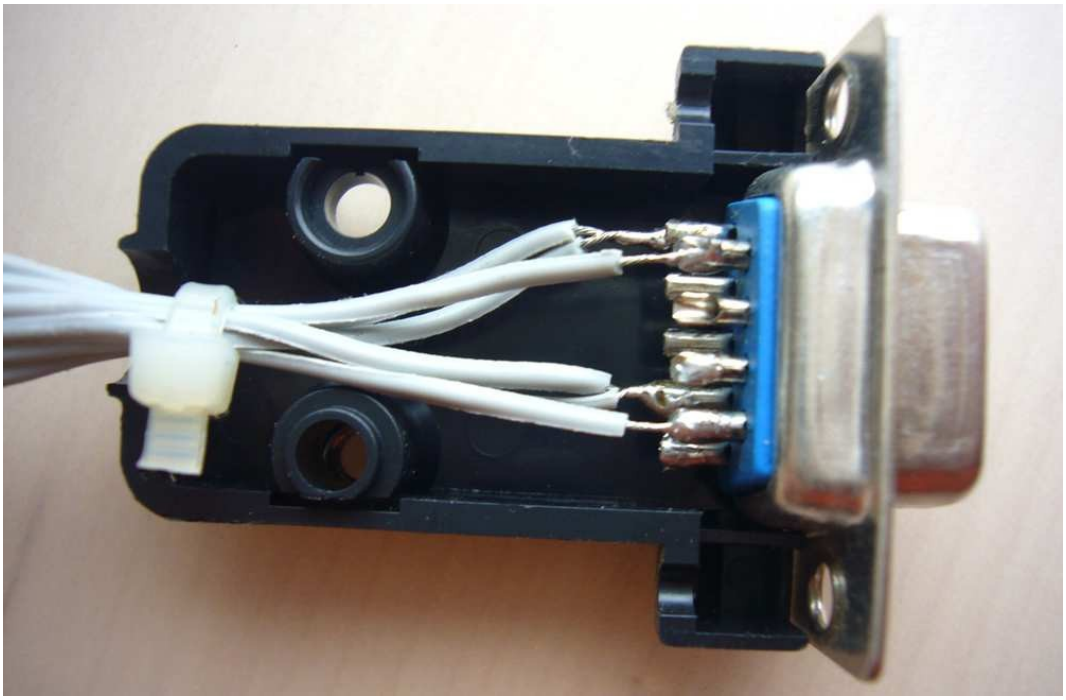

Figure 14. Detail of the interior of the VGA connector where four cables were connected to two pins of the connector. André Rangel 2010.

Maintaining the principle of economy and resorting to the reuse of materials, which in the context of this research can be considered [a] subversion of their functionality, a survey of the most common connectors was carried out in order to choose the most suitable one. The RJ45 and [RJ11] connectors, the sVHS connector and the VGA connector were considered as possibilities. Given its size and robustness, the VGA connector was chosen because, in addition to having space inside to solder/connect the two pairs of cables mentioned above, it ensures a secure connection, as the male and female parts of these connectors are secured by a pair of threaded screws and nuts. The choice of this multi-pin connector greatly simplified the assembly of the hyperinstrument because it is no longer necessary to connect four cables one by one. Another reason for choosing the VGA connector is that the male and female connectors only fit in a single position, which ensures that there can be no mistake in the four connections.

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354 The subversion of the functionality of media as a characteristic of intermedia was discussed in the section 'Ready Made and Happening'.

355 This type of connector was considered a strong possibility, given the ease with which they can be used, as they are the connectors used in network and telephone cables.

In this way, the transport of electrical current between the potentiometers and the microcontroller was done in a visually discreet and physically robust manner.

One might consider that the type of details just described are not relevant to the outcome and materialisation of the work, nor worthy of consideration in the writing of this text, but the opposite is true. As mentioned above, it is a question of semantics, of the semantics of materials; these are aesthetic as well as functional choices. They are therefore worthy of consideration and description in order to support the written rationale that explains the process of conception and elaboration of the work. Choices such as the type of cable used to carry electrical current are as important as the choice of pigment in a painting. A specific cable — with a certain diameter, with a certain flexibility — and not another, in the same way that in a painting one chooses watercolour and not oil, or 'this' yellow and not 'that' yellow. The transformation, subversion and adaptation of media, reconfiguring their original functionality, is an affirmation of the central activity of intermedia practice: the reciprocal transformation of media. In ColMus, the *'flat* cable' — normally used inside electronic objects — is used outside the object. At its end, a VGA connector
— , whose functionality and conventionality have been adapted, transforming it into a mere connector for [data] transport.

Switch

In addition to the two potentiometers that control the melodic line and the rhythmic speed of the algorithmic composition, respectively, the hi-fi interface

356 This involved a transformation of convention, protocol and coding, since in fact both the analogue video signal and the signal sent from the potentiometers to the microcontroller are merely variations in electrical voltage.

The ColMus hyperinstrument also incorporates a device that triggers the composition calculation process. This device was designed so that the algorithmic composition would only be calculated while a user was present, next to the hyperinstrument. In the absence of any user, the hyperinstrument only executes a progressive sequence of half tones from the diatonic scale, covering all the half tones of all the octaves that make up the tessitura of a piano. At the same time, it matches each half tone with the corresponding colour, according to the correspondence proposed by the ColMus work.

The device described below should therefore function as a switch, which turns on and off respectively by the presence and absence of a user near the hyperinstrument. In researching the design of the technical solution for this 'switch', various possibilities were considered and studied. In this practical research, three hypotheses for presence detection were developed and tested in some depth: using a video analysis system; using a passive infrared sensor; using a switch activated by a mechanical system. The video signal analysis system seemed inadequate. Firstly, because it involved the integration of another electronic device of some complexity, a video camera, and secondly, because it involved much more processing. Furthermore, it was considered inappropriate to use video signal analysis, which is so demanding in terms of computational processing, to perform a task as simple as activating and deactivating the algorithmic composition in ColMus.

The passive infrared sensor also proved inefficient because its function is to detect movement and not presence. If a user is standing

357 During this PhD project, experiments were conducted in the field of computer vision. A computer vision programme was designed and produced, and recent 3D video analysis technology was tested. The following section describes in some detail the practical research carried out in the field of video signal analysis.

A motionless object in front of the hyperinstrument would be the same as not being there. Therefore, after considering these possibilities, it was decided to use a simple pressure switch that would be activated by the presence — weight — users. Normally, these switches are designed to be used with the hands or fingers, but in ColMus, the intention was for them to function as a large pedal that could support the weight of any user. In this way, anyone standing in front of the hyperinstrument could press the pedal, immediately triggering the calculation of the algorithmic audiovisual composition. Given the fragility of the switch, it was necessary to design and build a mechanical system that would function as a pedal, capable of supporting at least 150 kilograms. This system, built of wood, includes an elastomer that allows the pedal to return to its initial position and turn off the switch whenever a user moves away from the hyperinstrument. To enhance visibility, for safety reasons and to encourage users to stand where the hyperinstrument is operated, two symbols — representing footprints — were placed in phosphorescent material.



Figure 15. Pedal/switch that triggers algorithmic composition in ColMus. André Rangel 2010.

Video signal analysis

During the practical research process that resulted in the ColMus work, several experiments in real-time video signal analysis were developed. Although this medium was not included in the work, for the reasons explained in the previous section, two practical approaches developed in this medium are now briefly described: the design and production of a computer 'vision' programme; and experimentation with [358] the 'Kinect' device.

The computer programme that was designed and programmed allows the detection of presence and/or movement in different areas — cells — of a video image, defined by a customisable grid. Basically, with this programme, it is possible to determine a number of rows and columns of the grid that will define the different areas to be analysed in the video image. In each of these areas, it is possible to determine one of two modes of analysis to be calculated: presence detection or motion detection. In both modes (presence or motion), it is possible to adjust the sensitivity of each area, determining a brightness threshold to which the cell should react. In motion detection mode, a value per cell is calculated in real time, representing the amount of movement in that cell, giving the interaction model that integrates this programme a much more expressive level of variation and nuance. Detection is performed using a pixel brightness subtraction method. In the case of presence detection, the brightness value of the pixels in the current video image is subtracted from the brightness value of the pixels in a reference image. For motion detection, the brightness value of the pixels in the current video image is subtracted from the brightness value of the pixels in the immediately preceding image. This programme has been simplified to make it easier to configure and use. The video digitiser that integrates this programme allows video signals to be acquired from cameras connected via USB or FireWire.

358 http://www.xbox.com/en-US/kinect

ensuring that most domestic and professional video capture systems were usable and compatible with the system.

The practical research in this PhD also aimed to explore recent technologies. On 10 November 2010, a new control device called 'Kinect' became available in Europe. This controller uses a technique called 'structured light' to produce a depth map, implemented with an infrared light coding system from the company 'PrimeSense'[359], and consists of a synchronous 'multi-sensory' device composed of an infrared light emitter and a coupled 'chip' (CMOS sensor). Depth acquisition algorithms measure the time interval between the emission of light and its arrival after being reflected by objects to each of the 307,200 (640 x 480) photodetectors. These time intervals are addressed with an 11-bit definition, allowing for 2048 sensitivity levels. All the different distances - time intervals - are represented by brightness values - grey levels - in a 640 x 480 pixel video image. It is, therefore, an image that represents the depths of a given scene. In this image, the brightest pixels correspond to the closest locations and the darkest pixels correspond to the most distant locations.

Although this controller was designed for a games console, it seemed very important to explore it as a component of an audiovisual expression tool. To this end, a computer programme was designed that, in a first approach, was capable of determining two-dimensional coordinates of objects at different depths (distances from the camera). To this end, spectra were defined in the distance values in order to isolate different spaces at different depths. Using a data mapping process, all values were converted from

359 http://www.primesense.com/

a specific range for a single value. Thus, any objects within that range were represented with a flat colour. To test this programme, a small exercise was developed where users can control the playback speed, duration and starting point of a video/audio file, as well as a real-time audiovisual transformation process, interacting only with their hands and body. After experimenting with this recent technology, it was considered that this was not a 3-dimensional computer vision system, but rather a 2+1-dimensional one, as the type of information collected from each of the dimensions (of the three orthogonal Cartesian axes) is not consistent. Given the number of photosensors available in the camera (640 x 480), there is a maximum limit of 480 possible values for height coordinates, 640 values for width, and 2048 for depth. However, after exhaustive experimentation, it was concluded that this controller is extremely robust and the fact that it uses infrared light allows it to be used in different artificial light environments. Despite its efficiency, the means described in this section are not suitable for the ColMus project.

SCULPTURE

The main objectives that guided the construction of the physical, material, and sculptural components of the hyperinstrument at ColMus were: low cost, robustness, ease of transport, ease of assembly, and ergonomics that would cover the widest possible range of physical builds and ages of users. The hyperinstrument consists of two main elements: a volume — referred to in this text as a box — which houses all the electronic components (computer, microcontroller, and video projector), and a metal arch, where the controllers are accessible for use by users. The need

need to design and implement these two elements guided the reflective practical research that resulted in this work, a hybrid practice between sculpture and equipment design.

ELEMENT 1: BOX

In order to ensure low investment in materials, it was decided that the sculptural component of ColMus should be constructed as much as possible from reused or recycled materials. Given that recycling processes usually involve resources with a certain degree of complexity, and in order to simplify the research process, it was decided to reuse materials only. Regarding the protective box for the electronic devices, after considering several options, wood was chosen because it is a robust material with unique characteristics of rigidity, flexibility, elasticity and resistance (Spulle et al., 2006). Furthermore, wood is one of the oldest building materials. The wood that proved to be most accessible for reuse was pallet wood. This medium — the pallet — ultimately defined the design, appearance and aesthetic concept of the hyperinstrument sculpture at ColMus.



Figure 16. The 'box' of the hyperinstrument in ColMus. André Rangel 2009. Photograph by Jorge Rêgo.

The pallet is one of the greatest milestones in 20th-century industrial design and standardisation, revolutionising the efficiency of goods handling and storage, and even being considered a unit of measurement. Essential since the 1940s in the logistics of stacking and transporting volumes and goods, the wooden pallet has undergone several versions and *standards*. The best versions have a load capacity of up to 2 tonnes and a height of up to 140 cm per pallet (Knapton, 1999). The robustness of the pallet was considered sufficient reason for its use in the construction of the hyper-instrument, as in addition to

360 Verganti (2009) considers that the Euro pallet system redefined logistics, giving meaning and significance to moving loads, not because of its use as a tool, but because it defined standards and protocols that in some way raised barriers to producers outside the European Union.

361 The pallet is often referred to as a unit of measurement, for example, a pallet of beer or a pallet of firewood. Many warehouses, stalls, and vehicles are designed and built with multiple areas of the Euro pallet area.

362 Knapton (1999) reports that the 80 cm by 100 cm Euro-Pallet has a load capacity of 5 kN to 20 kN when the volume(s) are well distributed across the horizontal area of the pallet, with a storage height of up to 140 cm.

If it were intended for public use, it would have to simultaneously accommodate and protect sensitive and fragile electronic technology.

In keeping with the Dadaist tradition and/or *Readymade*[363], it was decided to reuse both the design of the *Euro-pallet* structure and the wood itself. Given that the *standard* dimensions of the pallets were larger than necessary, as the intention was to 'protect' and accommodate a laptop, a video projector and a microcontroller, it was decided to build an open box, respecting the structure and design of the pallet, but reducing its size. To this end, two pallets were dismantled, the length of their boards was reduced, and the pallets were reassembled, also reducing the spacing between the boards. These two 'mini-pallets' form the sides of the hyperinstrument box in ColMus. As an intermediate work, ColMus confirms the characteristics mentioned in the chapter 'Background and (in)classification', particularly with regard to the subversion of the functionality of means and their transformation. The function of the pallet is no longer a modular transport base, but has been transformed into an outer protective box.

363 When referring to the Dadaist tradition, we consider the frequent formal, conceptual and material reuses of many of the authors who made up this movement. Previously, in the section 'Futurism and Dadaism', we referred to Marcell Duchamp's work 'Fountain', where a urinal is reused to fulfil a new function: a work of art. Another Dadaist example is Tristan Tzara's instructions to reuse newspaper articles and the paper itself to produce random poems: *'In order to make a Dadaist poem, take a newspaper.*
Take a pair of scissors. Choose an article of the length of the intended poem. Cut the article out. Then cut out each of the words which comprise the article and put them in a bag. Give the bag a light shake. Then take out one snippet after another, just as they come. Write everything down conscientiously. The poem will be similar to you.' Tristan Tzara, 1916 (Quoted in Elger, 2004, p.13)



Figure 17. Representation of the exploded 'box'. André Rangel 2009.



Figure 18. 'Transparency' of the box. André Rangel 2009.

The structure of the box consists of 26 wooden slats in four different sizes. The fact that there is space between the slats not only lightens the visual weight of the object's volume, but also creates a play of 'transparency' and opacity, giving the hyperinstrument an educational character, as it allows the viewer to observe all the technological resources used for its operation inside. This idea of 'transparency' gives the work another 'layer' of information about how the object is constructed and how it works. This 'layer' may not be intelligible to most people, but it certainly is to other creators in the field of intermedia arts and may motivate other artists to construct hybrid works that integrate digital and analogue media. In other words, as a result of reflective practical research, the hyperinstrument is a *vessel* that contributes to knowledge in the field of intermedia.

Following the creation and presentation of ColMus, and while this text was being written, several reuses of the pallet, or its wood, were identified in concepts and creations in the fields of Art, Design and Music, both before and after the date of the first presentation of ColMus. In fact, the pallet has been used repeatedly as a module and as a reusable material for construction. From Bob Taylor's guitars, manufactured since 1995; to Matthias Loebermann's 'Pallet Pavilion', designed for the 2005 World Ski Championships; or Schnetzer Claus and Pils Gregor's 'Pallet House', which was a success at the 2008 Venice Architecture Biennale; or

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364 The box is parallelepiped in shape with a square base, with a volume of 172,396.25 cubic centimetres, is 61 centimetres high and the base is 51.5 centimetres wide. It is constructed from 25 wooden slats with the following dimensions: 5 measuring 51.5 x 7.5 x 1.5 cm; 14 measuring 63.5 x 7.5 x 1.5 cm; 4 measuring 51.5 x 6 x 3 cm and 2 measuring 48 x 7.5 x 1.5 cm.

365 The Taylor guitar brand has been industrially producing guitars by reusing wood from pallets since 1995, when Bob Taylor built the first guitar to prove that it is the design and construction, not the wood, that makes a great guitar: http://www.laguitarsales.com/pages/3157/Taylor_Custom_Shop_Pallet.htm

366 Matthias Loebermann used 1,300 pallets to build a structure 6 metres high, 8 metres wide and 18 metres long, which was used as a meeting point for participants in the World Ski Championships held in Oberstdorf, Germany, in 2005. http://www.aml-partner.de/palettenpavillon-bilder.htm

367 Awarded at the Venice Biennale in 2008, the 'Pallet House' by Gregor Pils and Andreas Schnetzer from the Vienna University of Technology was built using 800 pallets. The house has already been assembled (and dismantled) in Venice, Vienna, Paris, Brussels and Linz.
http://www.palettenhaus.com/
http://studentcompetition.citechaillot.fr/2008/winningprojects/PH_winningprojects01.html

by exhibitors Alex Axinte and Cristi Borcan[368] for the Dalles room in Bucharest in 2010; to the furniture line by 'Studiomama 369' directed by Nina Tolstrup in London; or, in the national context, the recent set design by Pedro Tudela for the play 'Alma'[370]; there are several reuses of the pallet or its wood.

ELEMENT 2: ARCH

The second element that constitutes the sculptural component in ColMus is the metal arch, which supports two rotary potentiometers. These are the point of contact between the fingers of the users/performers and the interactive system of the hyperinstrument. The function of this second material is completely different from that of the wooden pallet. In this case, the two potentiometers that constitute the system's input are extremely light, fragile, small in size and must be exposed in order to be manipulated by users. Therefore, unlike the pallet, this second material would not have to protect, but only support. Thus, materials with high resistance and some flexibility were investigated, but which would allow for a 'light' visual appearance. The result of this research determined that metal was the solution that would provide a resistant support and, at the same time, could be thin enough to maintain the desired visual lightness. After considering different metals, such as aluminium[371], iron, and zinc, and in order to maintain the criterion

368 The Romanian architects Cristi Borcan and Alex Axinte, who run StudioBasar, designed and built a scenographic project for an architecture exhibition at Sala Dalles in Bucharest in 2010. These architects chose pallets as the basic unit for their entire scenography concept due to their low cost and ease of handling.
http://www.studiobasar.ro/?p=2320&lang=en

369 The 'Pallet Project' by designer Nina Tolstrup comprises a set of instructions for building a line of furniture by reusing wooden pallets. This line comprises two bench models, a chandelier, a floor lamp, a hanging lamp, a high chair and a low chair.
http://www.studiomama.com/

370 Pedro Tudela used various wooden pallets as a scenic element in Gil Vicente's play 'Alma', staged at the São João National Theatre in Porto between 12 and 28 April 2012.

371 Aluminium was a strong candidate as it is the only 100% recyclable material.

However, due to low financial investment, iron was chosen, specifically reused iron.

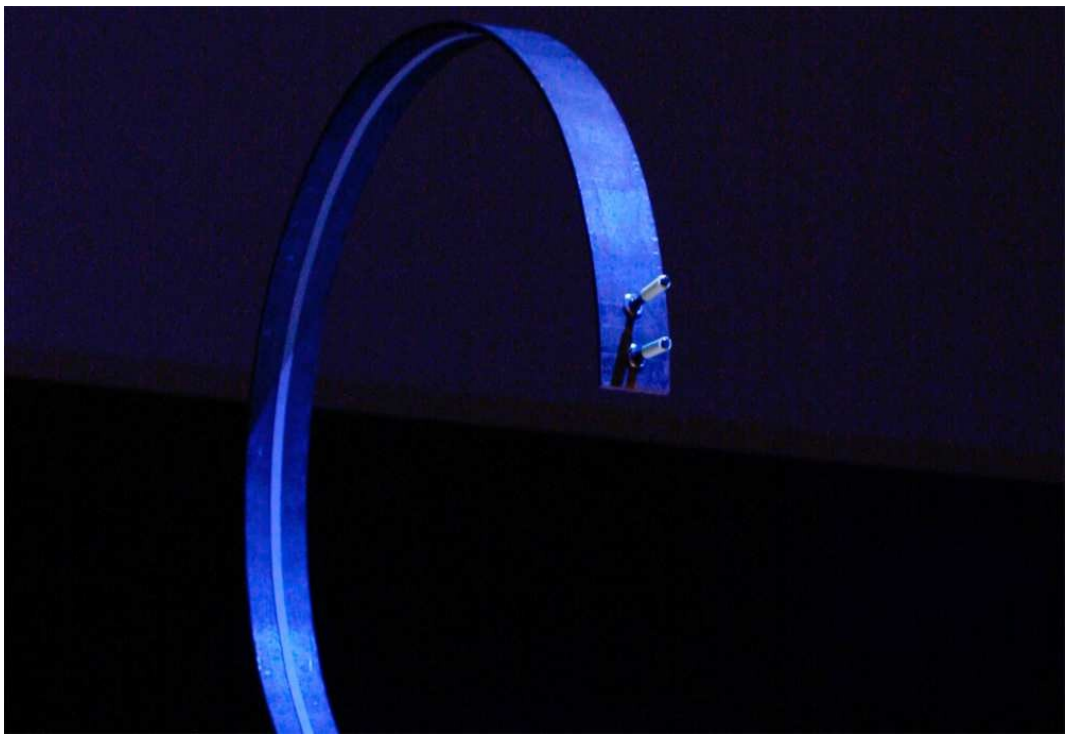

Figure 19. Iron arch. André Rangel 2009.

As a raw material, iron is much more recent in human history than wood, but it is still one of the oldest materials and remains one of the most important today in the construction of various objects that surround us. Iron gave its name to an important period in history, the 'Iron Age', which 'succeeded' the 'Bronze Age', although some specialists, such as John Percy, consider the process of iron production to be simpler and prior to the process of bronze production[372]. Knowledge and skills in ironworking have long been of crucial importance in the development of Western aesthetics and have always been associated with mental and cultural progress. The iron bow

372 *'It always appeared to me reasonable to infer from metallurgical considerations that the age of iron would have preceded the age of bronze. The primitive method, not yet wholly extinct, of extracting iron from its ores is a much simpler process than that of producing bronze, and indicates a much less advanced state of the metallurgical arts.*' John Percy, 1885 (Quoted in Swank, 2011)

373 *'If we refer to the history of the past, and trace the change from barbarism to a state of intellectual culture, we see at every step the contrivances and appliances of the "cunning workers in iron." These have always been the associates of mental progress, and the forerunners of supply to the wants and necessities of our social existence.*' (Fairbairn 1869, p. iv)

The support for the hyperinstrument's potentiometers was modelled using only traditional techniques, with a hammer and anvil. The iron, which was reused, came from a rectangular bar recovered from an old gate.

UNIFYING CONTRAST

The combination of wood and iron reinforces the contrasts that form the ColMus work. Despite its hybrid nature, ColMus also features contrasts, which are listed below. The contrast between the mechanical characteristics of wood and iron as materials. The contrast of shapes: the wood forms a parallelepiped volume, structured by the repetitive parallelism and orthogonality of the wooden slats, where there are no curved lines. The iron, in contrast, forms a circular arc, behaving much more like a line than a volume. Neither material is painted or polished, allowing the natural colour and fibrous texture of the cut wood to contrast with the smoother, moulded and oxidised colour and texture of the iron. One could also mention, among others, the contrast between the human scale and the scale of the microprocessor, or the contrast between *software* and *hardware*[374]. Contrast is an unavoidable feature in artistic creation. The philosopher Stephen David Ross even considers Art to be a methodical construction of intense contrasts and contrast itself as a unifying[375] element.

Despite the unifying contrasts just listed, there are other elements that contribute to unification in ColMus, for example, the symmetry and metric relationship between the upper face of the parallel volume

374 *Software* and *hardware* also come together in what Greenfield (2006) calls *everyware.*

375 *'Art is the methodical construction of intense contrasts. […] We return to the unitariness of a work of art. A contrast is the unification within one order of constituents which are significantly different from each other. […] Art is the purposive creation of intense contrasts, […] Art is inventive because an intense contrast is created, not merely an amplification of an established relation. […] Art is construction, and its value lies in the distinctiveness of its works.*' (Ross, 1994)

lepipedic and the iron arch. The diameter of the circumference of the arch corresponds to the side of the square, which determines the plan of the wooden structure, i.e., the circumference to which the iron arch belongs is strictly inscribed on the upper side of the parallelepiped. Of the various possible relationships between a square and a circumference, three were considered for the design of the hyperinstrument: the circumference inscribed in the square, the square circumscribed to the circumference, and the classic *'Squaring the* Circle' challenge, in which a square with an area equal to that of a given circumference is sought. Using the criteria of alignment and ease of understanding by [376] the public, the first of the three relationships mentioned was chosen: the circumference inscribed in the square.

The iron piece is attached to the wooden box by four sets of steel nuts and bolts, allowing for easy disassembly, transport and storage. In addition to the contrasts described between wood and iron, these two materials, being the most visible from the outside, come together to form a single sculptural element. This element, in turn, establishes a new contrast, *low-tech/high-tech*, with all the electronic components that are less visible inside the hyperinstrument.

Knowing that the categories *low-tech/high-tech* are neither rigid nor permanent, we do not intend to delve deeper into this dichotomy, since what may be considered 'high-tech' at a given moment may later be considered [377] 'low-tech'. In the context of this research, the wooden structure and iron arch are considered 'low-tech', as traditional techniques and tools were used in the process of reuse, assembly and construction. All electronic components and software are considered 'high-tech'. This integrative 'high/low-tech' contrast is

376 In this case, when referring to understanding, it is considered something that may be unconscious, as there is equity between the measurement of the diameter of the iron arch and the measurement of the side of the base of the parallelepiped, but users will not consciously measure it.

377 *'But high tech does not stay high tech forever.'* (Naisbitt and Naisbitt, 2000)

accentuated by the almost rudimentary way in which iron and wood are juxtaposed with electronic systems that require a great deal of knowledge to understand and operate on a much smaller scale. Although high-tech objects can be associated with innovation, avant-garde and progress, and low-tech objects with little sophistication and tradition, both have the same artistic potential and value, affirming their equality as means in the intermediate fusion.

Another factor that highlights this contrast is the ‘transparency’ of the wooden structure, which allows the elements inside to be seen, namely all the electronic resources necessary for ColMus to function. The decision to concentrate all these resources inside the hyperinstrument was a practical and functional one. This way, only a power cable is connected to the hyperinstrument, so moving it does not involve any wiring or unwiring. The alternative would be to have the hyperinstrument divided into two locations, one for the control area and another for the processing area. However, this alternative would not favour the image of unity of means. It can be concluded that the hyperinstrument in ColMus has acquired a pedagogical and didactic level because it does not hide, but rather shows, in a 'transparent' way, all the mechanical and electronic devices used inside it, as well as how they are interconnected. In this way, the public can understand the level of complexity and what kind of resources are necessary to construct this type of work.



Figure 20. Presentation of the ColMus project at the Portuguese Catholic University. André Rangel 2009. Photograph by Jorge Rêgo.

DETAIL

It can be concluded that all these details — from the colour and thickness of the wood or iron bar of the sculptural component, to the colour or thickness of the cables used, or the colour of the heat-shrink sleeve[378] — constitute the materiality of the hyper-instrument in ColMus. The originality and nuance of the work are accentuated precisely by the choice and combination of these details, affirming the saying *'God is in* the detail'[379], which is a maxim appropriate to any process of design and artistic composition. This concern for detail, which is part of the good training of most architects and designers, is undoubtedly contaminating other areas of creation and knowledge.

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378 Heat-shrink tubing is a mechanically expanded polymer tube that shrinks in diameter when exposed to heat. It is used for electrical and electronic insulation. For more information on this material, please visit the following website: http://en.wikipedia.org/wiki/Heat-shrink_tubing

379 Translation by the author from the original: 'God is in detail'. Although there is no consensus on who coined this phrase, Shankman and Durrant (2000) identify historian Aby Warburg as its author.

SoLu

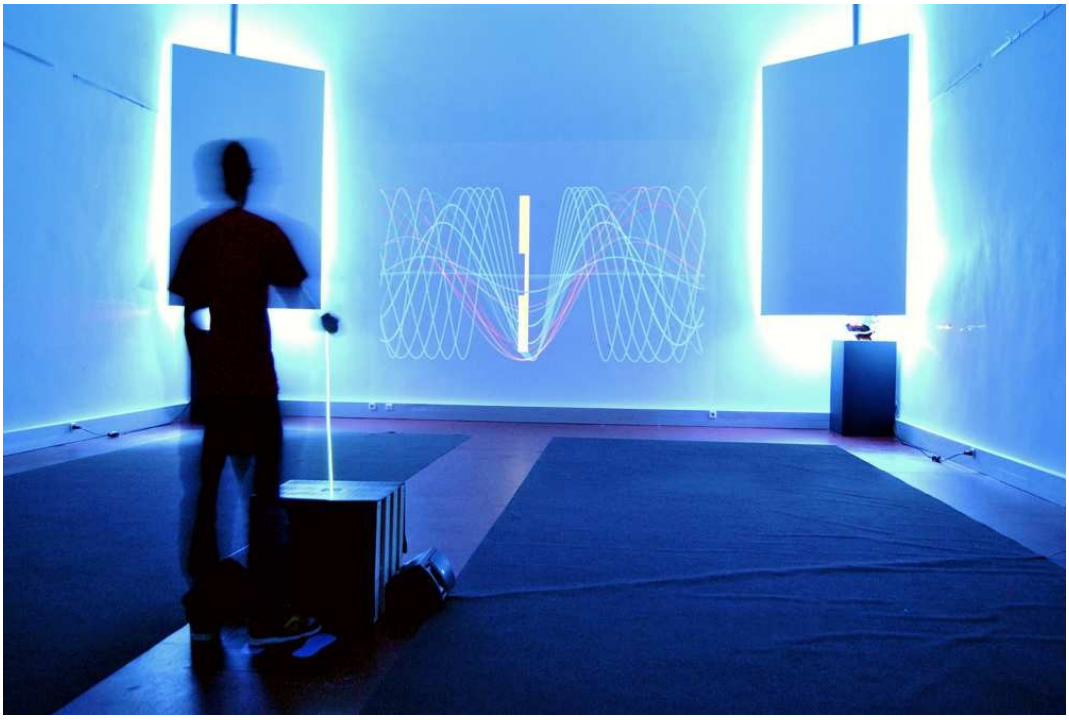

Figure 21. SoLu artwork at the Portuguese Catholic University. André Rangel 2010.

The work SoLu [380] is a *redesign* of the work ColMus, which arose from the need to demonstrate at the 'EVA Conferences International 2010' in London the theoretical proposal of correspondence between light and sound developed during this doctoral project. After submitting a written article for this conference, which presented and described the aforementioned theoretical proposal, its Scientific Committee, based on one of the reviews carried out by specialists, decided, in the person of Dr Stuart Dunn, to invite the researcher and include a demonstration of the correspondence proposal in the conference programme.

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380 http://3kta.net/3solu.php

381 A series of events on 'Electronic Information and Visual Arts', organised locally for people interested in technology associated with the cultural sector. Among other locations, EVA conferences are held regularly in Berlin, Florence, London and Moscow. More information at: http://eva-conferences.com/

382 One review described the article as 'impressively well researched and written' in a notification sent on 14 February 2010 by the scientific committee of the EVA London 2010 Conference.

383 http://www.kcl.ac.uk/innovation/groups/cerch/people/dunn/index.aspx

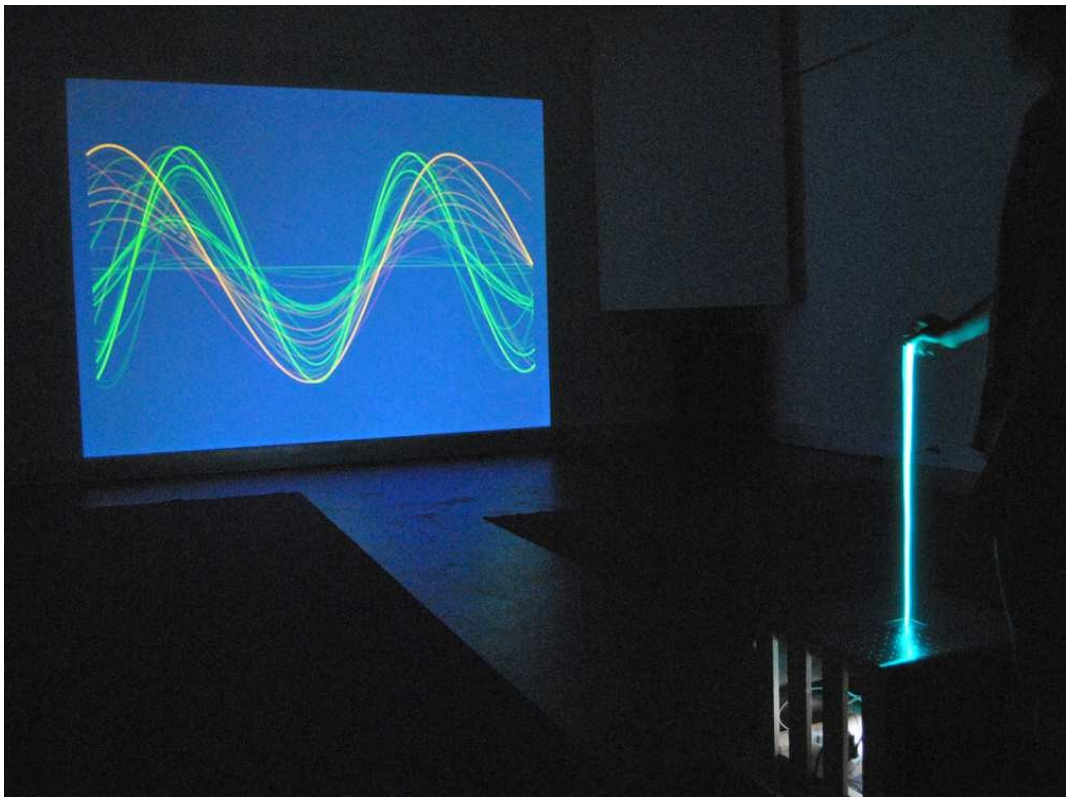

Figure 22. SoLu work at the Portuguese Catholic University. André Rangel 2010.

As this was a demonstration of the theoretical proposal in London; as it was a demonstration at a specialised conference, where topics such as ‘Electronic Visualisation Technologies in Art, Design and Performance’ were discussed; and despite the existence of the ColMus hyperinstrument described above, it was decided for two reasons to create and produce a new hyperinstrument.

The first reason was mainly a matter of visualisation. This time, the aim was to make the demonstration of correspondence more intelligible and objective. To this end, visual events were programmed, generated in real time, presenting sinusoidal waves with a wavelength proportional to the wavelength of the projected and observable light colour. Remember that this colour is determined according to the process described in the section 'Correspondence proposal', i.e., in SoLu, the correspondence between the frequency — Hz — of the sound heard and the wavelength — nm — is also established, which, when converted to the RGB colour space, results in the colour of the projected light that is observed.

wave length — nm — which, when converted to the RGB colour space, results in the colour of the projected light that is observed.

The second reason, related to the sculptural, physical, structural and material aspects of the hyperinstrument, was due to logistical and economic constraints, leading to the decision to develop an object that could be easily transported in the hold of an aeroplane.

Thus, reflective practical research developed into a process of total *redesign* of the ColMus hyperinstrument, in order to obtain a new hyperinstrument that would maintain a sufficiently large size, for ergonomic reasons, in relation to the users' bodies, but which, at the same time, could be reduced to less than 50% of its volume for transport and travel. This challenge was solved by designing a structure that is easy to dismantle and pack. The process of *redesigning* the structure and volume of the hyperinstrument fundamentally involved solutions that ensured low production costs, robustness, functionality, a drastic reduction in volume (when dismantled) and efficiency and speed in assembly and dismantling.

The invitation to the demonstration in London took place on 4 May 2010 and the presentation took place on 6 July of the same year. For about 60 days, the process of reflective practical research integrated all the tasks inherent to the problem of prototyping the 'SoLu' hyper-instrument, from its conception (visual design, sound design, sculptural design, electronic system design, meta-conception of musical and visual composition, software design, interface design, interaction design) to its production (testing and implementation of concepts, software programming and construction). The presentation of the results of this practical research in London caught the attention of Professor

Dr James Hemsley [384], founder of the EVA conference, who extended a new invitation to present SoLu at the Berlin conference held at the Kulturforum on Potsdamerplatz on 11 November 2010.

The reference to presentations at international conferences may seem inappropriate in the context of this text, but in fact, it was these opportunities that triggered the main redefinitions in the SoLu project as a process of *redesigning* the ColMus project. The following paragraphs describe the main developments in reflective practical research in the process of developing SoLu. These developments are: replacement of the two ColMus potentiometers with a rod in SoLu; reduction in the volume of the box and the number of parts that comprise it; introduction of a vibration sensor to accentuate percussive events.

FROM THE BOW TO THE ROD

In ColMus, the diameter of the iron bow, where the control potentiometers are located, is too large to fit inside a 'normal' hold bag, so it was the first element to be reconsidered. The redesign of the hyperinstrument interface aimed at greater simplicity of use and an expansion of gestures. In ColMus, the point of physical contact between the user and the hyperinstrument are the rods of two potentiometers, fixed to the metal arch, which control the melodic line of the composition and its rhythmic speed, respectively, as described above. Both hands are needed to move these potentiometers simultaneously.

384 http://en.wikipedia.org/wiki/James_Hemsley

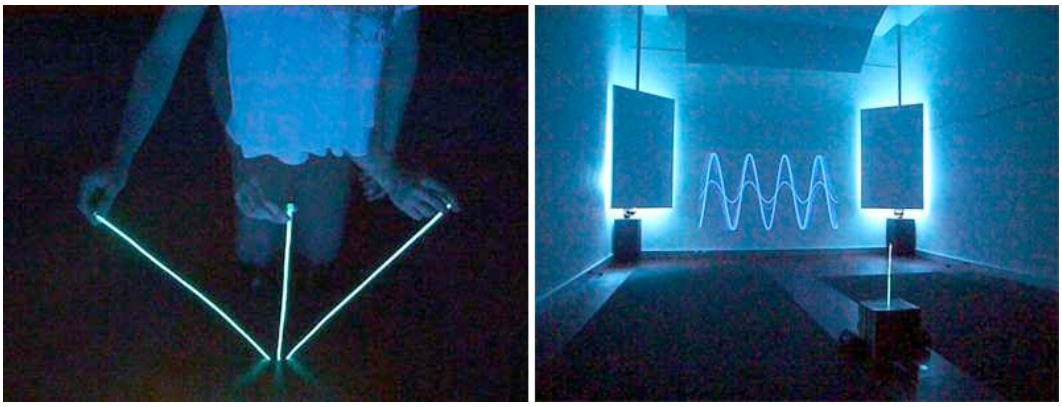

Figure 23. Movement of the rod and application in the work SoLu. André Rangel 2010.

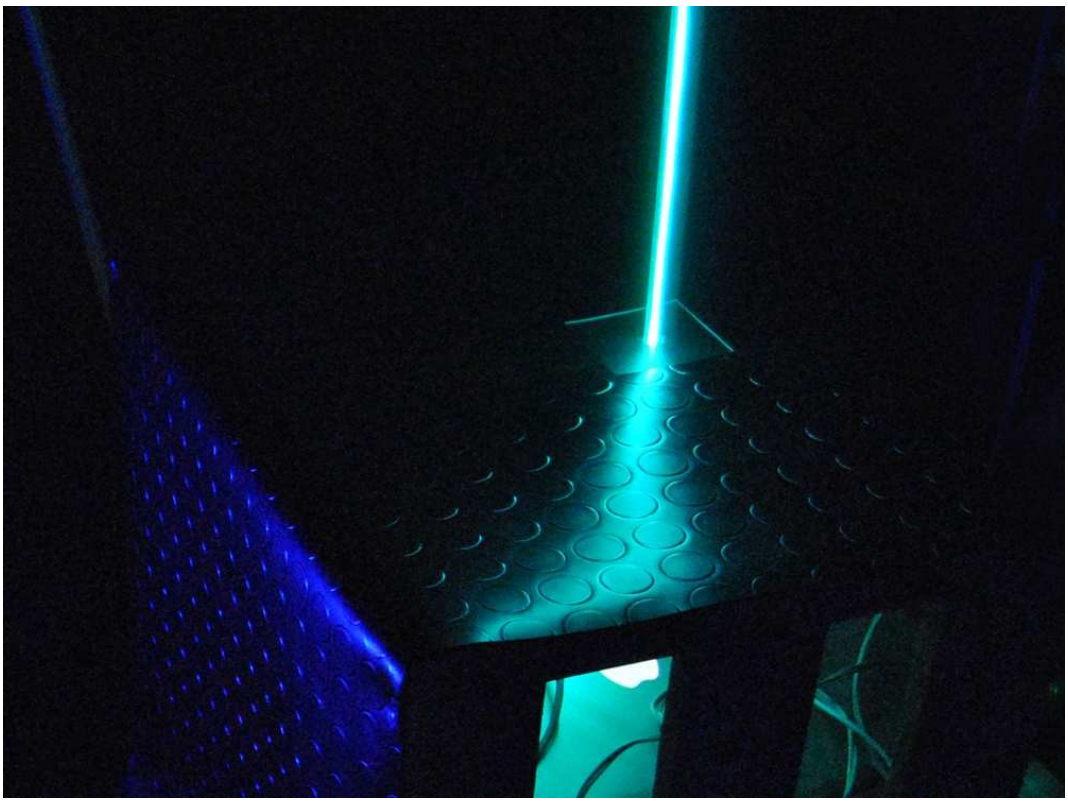

Figure 24. Light rod of the hyperinstrument in SoLu. André Rangel 2010.

As these potentiometers are fixed, the gestures are very reduced and limited to the rotation of each of the rods at a maximum amplitude of 270º. Thus, inspired by the image of the Maestro and his baton, we moved forward with the design of an interface that would allow the SoLu hyperinstrument to be controlled with just one hand, but in such a way that the users' gestures and the range of their movements would be increased. This new interface, in addition to being operated with just one hand, should

continue to allow the simultaneous sending of two variables to the hyper-instrument.

The high 'hardness' of the baton, combined with the attraction of a plant-based inspiration, specifically the grass[385] commonly known as 'reed', which is found in some dunes in Portuguese coastal areas, sparked a new challenge: to build a tangible, flexible interface that would allow simultaneous movements in at least two axes. Guided and inspired by the natural structure of the reed, which moves like an inverted pendulum, fixed at its root, and whose stem moves around the central position, practical experimentation was carried out with a view to structuring the new interface, which resulted in a rod.

The ‘conversation’ with the process of materialising the rod — interface — led to the following constraint: as it is an interface for an audiovisual hyperinstrument to integrate an intermedia work, which also generates visual content in the form of video projection, its operation requires a darkened environment, so the rod should be somehow luminous or capable of reflecting light. In the search for a solution to this constraint, practical research focused on luminescent, fluorescent and phosphorescent materials. This research resulted in the choice of *EL-Wire*[388] — an electroluminescent wire that was chosen for its high brightness and the invariability of that brightness.

For the production of the flexible luminous rod of the inverted pendulum, various materials were experimented with and tested, mainly rubbers.

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385 The inspiration comes from two types of grass in particular: *Ammophila arenaria* and *Elymus farctus*. Porto (2007) writes in the Digital Herbarium of the University of Coimbra: "[...] this is what happens in the dunes. These formations depend on two species of perennial grasses that grow there – Ammophila arenaria (marram grass) and Elymus farctus.”

386 An inverted pendulum is a simple pendulum whose centre of mass is located above its fixed axis. For a definition of pendulum, see: http://pt.wikipedia.org/wiki/Pêndulo

387 The central position of a pendulum is also called the equilibrium position. In the context of our text, the central position of the reed means the position in which the stem is hypothetically vertical.

388 http://en.wikipedia.org/wiki/Electroluminescent_wire

natural and synthetic, silicone and polymers. Given its mechanical characteristics - hardness/flexibility ratio - and because it allows the introduction of an electroluminescent wire inside it, the extruded, transparent acrylic tube with a very small diameter was the material chosen.

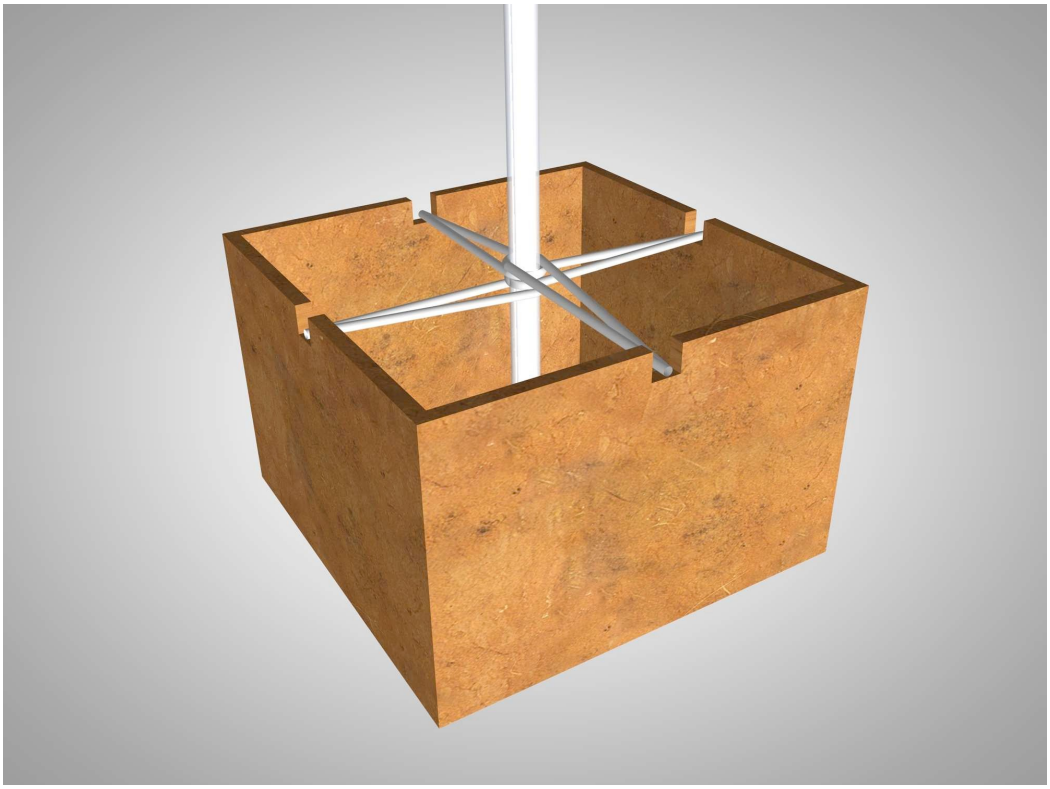

Figure 25. 3D model of the elastomer system. André Rangel 2012.

The next challenge, perhaps the greatest, in the creation of the luminous rod, was the support and fixing of the rod — an acrylic tube — so that it could function as an inverted pendulum. Once again, he immersed himself in a practical dialectical process [389] to design the solution: a mechanical system integrating four [elastomers 390] positioned horizontally, exerting traction on the rod in four directions separated by 90º angles, which allow the pendulum rod to move, making it

389 In this process, various mechanical hypotheses were tried and tested to keep the acrylic tube in a vertical position, from different metal springs to natural and synthetic sponges of various consistencies.

390 The four elastomers are positioned horizontally, exerting traction on the rod in four directions separated by angles of 90º.

always return to its central position, the vertical position (see figure). The result was a luminescent rod that could be operated like a *joystick*.

VIBRATION OF THE ROD

Following its presentation at the *EVA 2010 Berlin* conference, an article written about the SoLu project was selected to be included in the programme for the 13th Generative Design conference in Milan — GA2010 — scheduled for December 2010. This time, Dr. Celestino Soddu, director of the conference, requested that instead of presenting the written article, the work be presented in a live performance format. This request motivated a new development and improvement in the hyperinstrument in SoLu. At this point in the research, a phase of practical exploration of motion capture sensors was completed, which took place during November 2010. Simultaneously, based on reflection on previous presentations of the work, the potential of the luminous rod of the hyperinstrument in SoLu was realised: the flexibility of the polymer of the rod. This finding triggered a new development in the work: it was decided to enhance the hyperinstrument's interface by introducing a vibration sensor in order to add nuance and variation to the interactivity.

While in ColMus users only manipulate two variables using two potentiometers, in SoLu, in addition to the two variables, abscissa and stem distance, users can now control a third variable: stem vibration. In addition to the movement of the rod (forward, backward, left and right), it was decided that interaction would be expanded if the user could 'hit' the rod, as with a percussion instrument, and if these beats could also be 'felt' by the system and used — in

391 http://www.eva-berlin.de/index.php?article_id=56&clang=0

392 http://www.generativeart.com/

algorithm input — as a way of controlling the audiovisual events generated by the hyperinstrument. In order to enable the measurement and digitisation of the vibratory movement of the user's beats on the rod, devices and sensors capable of doing so were investigated. Previous laboratory work, developed during this PhD, was reviewed, as experimentation with various types of motion capture sensors, focused on the study and testing of the dynamics of three types of sensors: accelerometers, vibration sensors (*balance/cantilever* type), and *piezoelectric* ceramics. It was concluded that to measure the vibration of the rod, it was appropriate to explore the potential and sensitivity of piezoelectric ceramics and vibration piezos (balance type) constructed on flexible film. The latter type of sensor was chosen for several reasons, including its excellent performance in detecting vibration and impact, and for reasons of formal, plastic and aesthetic consistency: as it is constructed from transparent flexible film, its relationship and integration with the transparent polymer rod proved to be suitable. Of the various vibration sensors available on the market, the flexible LDT-028K[393] vibration sensor was chosen due to its small size (12 x 26 x 0.04 mm), high sensitivity and transparency. After the genesis of SoLu — prompted by Dr. Stuart Dunn's invitation — the introduction of this sensor was another important event in the history of the design of the hyperinstrument for this work.



Figure 26. Application of the sensor at the top of the rod. André Rangel 2010.

393 The basic piezo sensor chosen is normally used for flexibility, vibration, touch and shock measurements. It is manufactured by Meas-Spec (Measurement Specialities - http://meas-spec.com/), a company specialising in the design and manufacture of sensors and sensor systems. The sensor reference is LDT0-028K and its specifications can be found in the following document: http://dlnmh9ip6v2uc.cloudfront.net/datasheets/Sensors/ForceFlex/LDT_Series.pdf

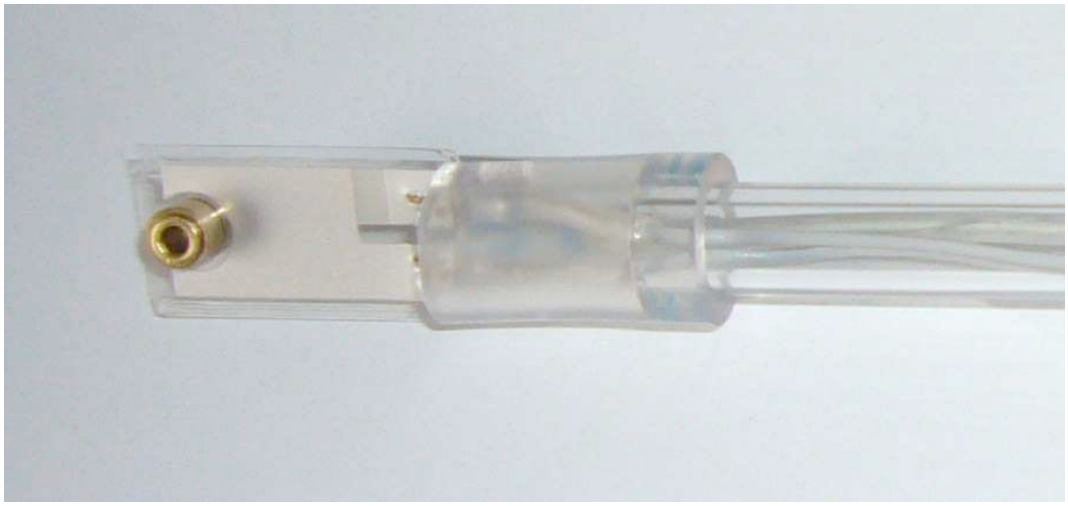

Figure 27. Detail of the sensor application at the top of the rod. André Rangel 2010.

The integration of the sensor, given its size and fragility, was in itself a design challenge. As it is an aesthetic solution rather than a technological one, the major challenge in integrating this sensor was mounting it on the luminescent rod, which is only 8 mm in diameter. Another major challenge in integrating the sensor was due to the fact that the hyperinstrument in 'SoLu' was designed for easy transport on aeroplanes, so the assembly/disassembly of the sensor had to be efficient and robust before and after each performance.

For the correct integration and operation of this sensor in a hyperinstrument that produces visual and sound events, it was necessary to carefully consider and reflect on its sensitivity. The risk of sound pressure (produced in the work) acting on the sensor was real. In order for the hyperinstrument to be used in live performance situations, where sound pressure is quite high, it was necessary to create a calibration, adjustment and limitation system. This need resulted in a hybrid solution - physical, analogue and digital: a small height-adjustable rubber cylinder was applied to the sensor in order to increase its resistance to vibrations (reducing its sensitivity in an analogue physical way); simultaneously, for the digitised sensor data, an algorithm was developed that allows an adjustable limit to be determined, from which the algorithm

algorithm responds to the sensor's vibration data. It should be noted that the design and implementation of the solution for integrating this sensor into the luminous rod was only possible through reflective practical research in an experimental laboratory context, in constant dialogue with the materials.

It can be concluded that the integration of this sensor expanded interaction in SoLu to the level of percussion, allowing users' stronger strikes or taps on the rod to instantly trigger an audiovisual response from the system. When redesigning the hyperinstrument interface to make it easily transportable, the usability of the interface was reconsidered, enhancing the gestures, simplicity of interaction, and freedom of the users/performers' own gestures.

LESS VOLUME

As mentioned in the section ‘From bow to rod’, the limitation on luggage size was one of the factors that triggered the redesign process of ColMus’s hyperinstrument, which resulted in SoLu. In addition to transforming the bow into a rod, the wooden ‘box’ was also transformed. In ColMus, the pallet is fully embraced as an aesthetic and cultural reference point, which is why the box cannot be dismantled, as all the slats that make it up are nailed together.

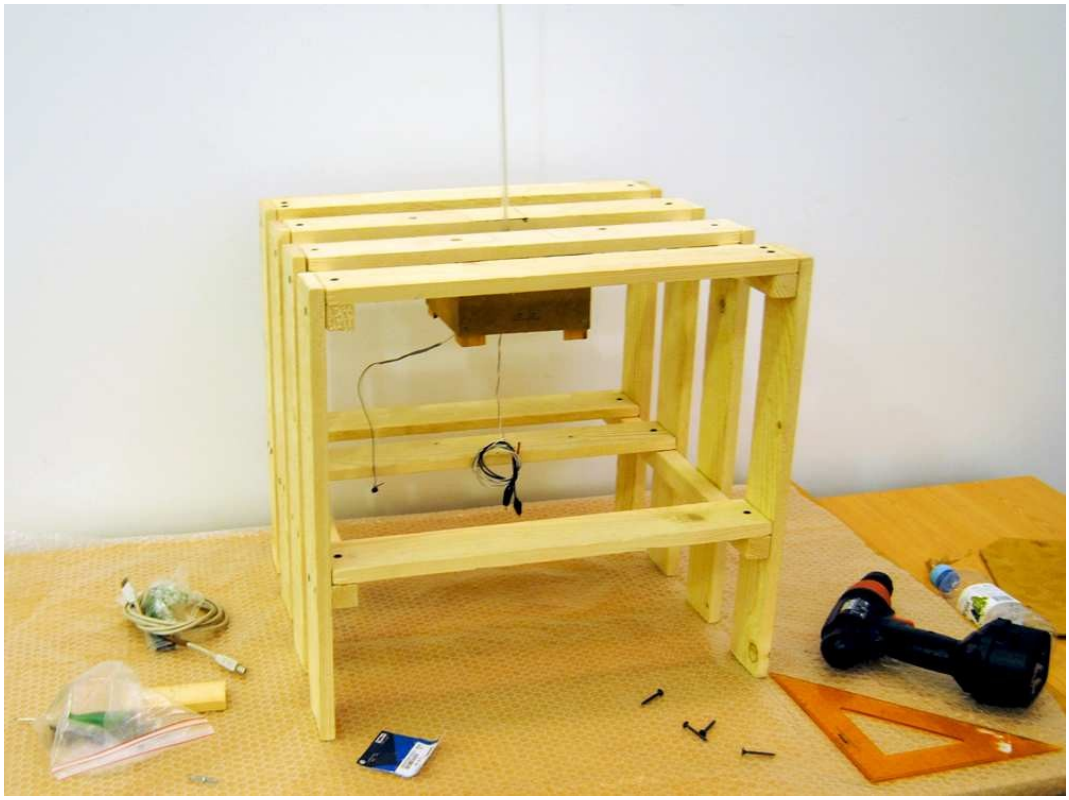

Figure 28. 'Box' of the hyperinstrument in SoLu. André Rangel 2010.

Given the need to travel with the work, at SoLu, the 'box' is designed with a view to reducing its volume, making it easy to assemble and, for reasons of identity, maintaining the appearance of a pallet. To this end, two decisions were made: to reduce the number of slats and to replace nails with screws. The box for the hyperinstrument at ColMus is a square-based parallelepiped with sides measuring 51.5 cm and a height of 65 cm. This box is constructed from 25 wooden slats and has a volume of 0.1724 m³. In SoLu, the box is a cube with 47 cm edges, constructed from 19 wooden slats (narrower and shorter than in ColMus), with a total volume of 0.1038 m³. This box was part of the SoLu project in four presentations: at the Catholic University when documenting the prototype and at conferences in London, Berlin and Milan. The process of redesigning the box resulted in a 39.8‰ reduction in its volume when assembled.

After presentations in London, Berlin and Milan, the SoLu project was selected for the world's most important conference on tangible interfaces, the TEI conference, which took place in January 2011 in Funchal. In anticipation of this presentation, the quality of the SoLu hyperinstrument box was reviewed. It was noted that as the box had already been assembled and disassembled four times, the screws no longer provided the same traction. Furthermore, as the work was to be presented at a conference (TEI) where design is a central theme, it was considered that the box and its construction should reflect a process of practical research aimed at simplifying the shape of the box and its assembly. These findings, combined with the desire to create a work whose interface could this time travel in an airplane's cabin luggage, triggered a new process of redesigning the hyperinstrument box in SoLu.

The first decision made in this process was to replace the system used to fix the slats that form the box. In order to ensure that the box could be assembled and disassembled without damage, the system of screws tightened directly onto the wooden slats was replaced by a system in which the wooden slats are drilled and fastened by sets of screws and threaded nuts. Given the cabin baggage restrictions imposed by airlines, particularly in terms of weight and volume, and also the need to transport the piece between the airport and the venue where it was to be presented, the structure and sculptural component of the hyperinstrument — the box — were redesigned in order to reduce the volume and weight of the dismantled piece.

This was the third major milestone in the design of this work, having been implemented in the sculpture workshops of the Faculty of Fine Arts.

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394 Conference dedicated to the presentation of embedded, incorporated and tangible interaction. The works presented usually focus on topics such as Human Computer Interaction (HCI), design, interactive art, usability, tools, technologies and computing. For more information: http://www.tei-conf.org/

University of Porto. The solution developed in this third phase of the box redesign maintained the cubic shape and determined that it should be constructed with only 8 rulers, which is less than half the number of rulers used in the previous version (19 rulers) and less than a third of the number of rulers used in the ColMus hyperinstrument box (25 rulers). While in the first version of the hyperinstrument box in SoLu the wooden slats are fixed to each other by screws that tighten directly into the wood, the 8 slats of the new box, which are wider and thinner than the slats used previously, are fixed to 4 aluminium L-shaped profiles that ensure the orthogonality of the sides of the box. The slats are fixed with stainless steel screws and nuts. It should be noted that these screws and nuts were chosen based on the criterion of the smallest possible volume. Thus, screws that are tightened with a hex key were chosen because they are much less bulky and heavier than a conventional screwdriver.

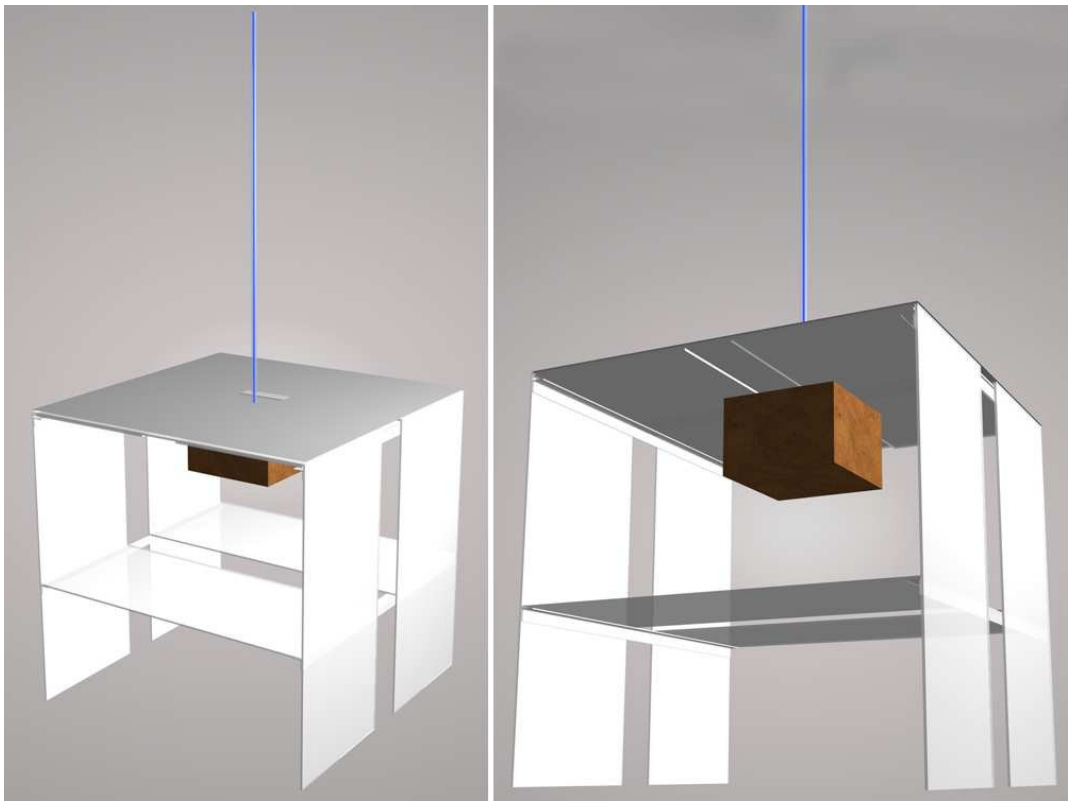

Figure 29. 3D model of the hyperinstrument 'box' in SoLu. André Rangel 2011.

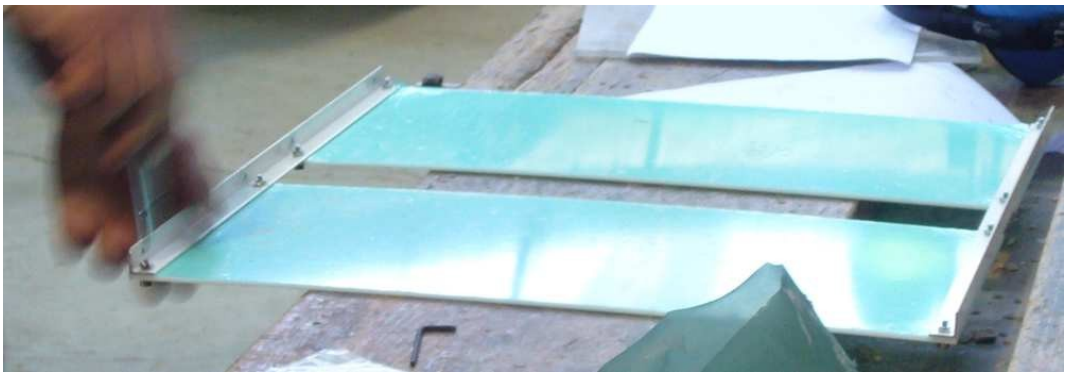

Figure 30. Construction of the 'box' with acrylic sheet rulers. André Rangel 2010.

The first box tested in this third phase of redesign was constructed with opaline acrylic sheet strips instead of wood. This solution had a light and translucent appearance, but its final weight was still considered excessive. Given the visual quality of this piece, it was decided to keep it in case of a presentation in Portugal, where it would not be necessary to fly. The exploration of other materials was therefore pursued. Synthetic materials — fibres and plastics — and composite materials made from wood

— chipboard and plywood. Considering the quality, weight, strength and price of all the materials tested, marine plywood and aluminium were chosen for the construction of the final version of the box for the hyperinstrument in the work 'SoLu'. Thus, when disassembled, the resulting box occupies a volume of 0.00316 m^3, which corresponds to a 98.2% reduction in volume compared to the volume of the ColMus box, which could not be disassembled.

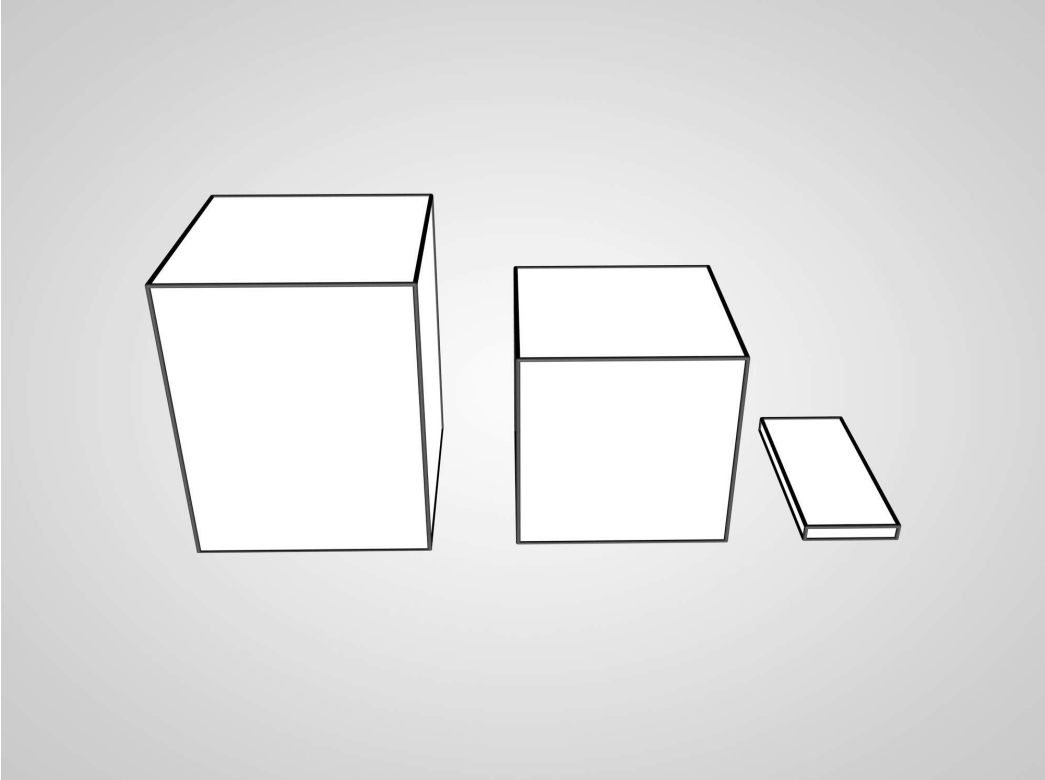

Figure 31. Comparison of volumes. From left to right: assembled ColMus box; assembled SoLu box; and disassembled SoLu box. André Rangel 2010.

It should also be noted that, during the box redesign process, another feature was discovered that allowed for a hybrid functionality of one of the materials used to construct the box: the L-shaped aluminium profile. This profile not only allows the plywood strips to be fixed in place, but also ensures the box is orthogonally aligned, as mentioned above. However, during the process, another functionality for this material was discovered, which will now be described. While studying the best way to package the materials needed for the presentation of the work, it was found that the edges of the plywood could be easily damaged during transport. The edges of the plywood strips are fundamental to the semantic value of the box as a means of the hyperinstrument in SoLu. The edges of these strips form the edges of the cubic box when assembled, so they must be read as straight lines. Any damage to one of the edges of one of the strips would compromise the reading of straightness, as a damaged edge would be read as a broken, irregular line rather than a straight line.

Thus, another seemingly simple challenge arose: what is the best way to package the rulers so that their edges are not damaged during transport?

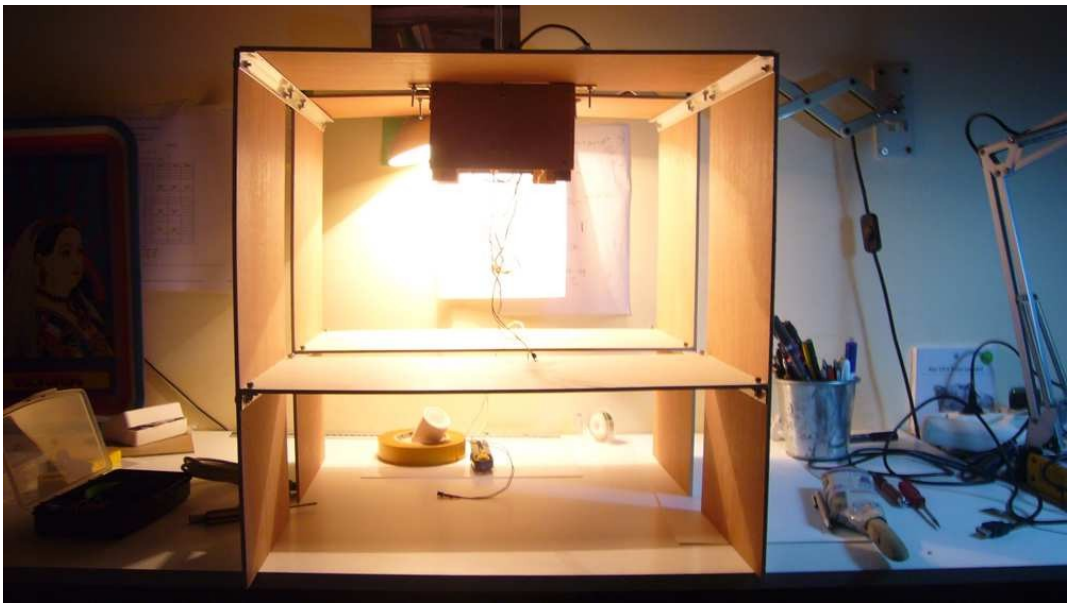

Figure 32. Prototype of the SoLu box made of plywood. André Rangel 2010.

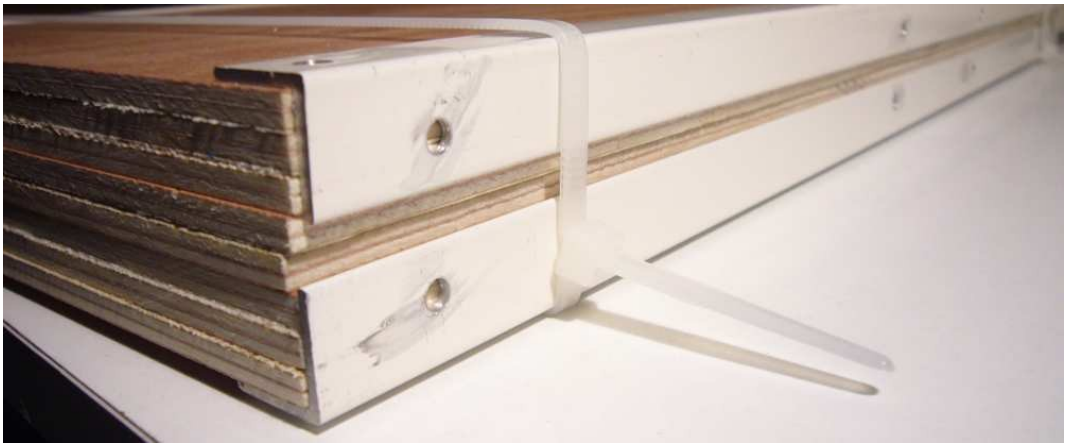

Figure 33. Packaged SoLu box rulers. André Rangel 2010.

When stacked, the eight rulers that make up the box form a parallelepiped 47 cm long, which is also the length of the four aluminium profiles. Dialogue and reflection on these materials led to a solution: use the aluminium profiles to protect the edges of the stacked rulers. This effective solution is the unconscious result of the initial decision to give the box a cubic shape in which all edges are the same length. This solution confirms the serendipity discussed earlier, which occurs in a research process involving

initial decision to give the box a cubic shape where all edges are the same length. This solution affirms the serendipity discussed earlier, which occurs in a research process in which intermediate dynamics between media are experimented with.



Figure 34. Demonstration of the hyperinstrument in Funchal. André Rangel 2010.

Pressure Switch

In the hyperinstrument of the work SoLu, it was also necessary to redesign the system — switch — that activates the algorithmic composition, as the system designed in ColMus to detect the pressure of the user's feet when approaching the hyperinstrument was very bulky. Several commercial solutions were investigated, but given the high cost and the fact that none of these solutions had the exact dimensions required for the project, it was decided to design and build a flat pressure sensor measuring 42 cm x 30 cm, with a total thickness of less than 1.5 mm. To this end, the specifications of other industrially produced pressure switches were researched and, once their operating principle was understood, a first version was built using paper and aluminium foil. This version was tested for several months and, once the necessary dimensions were determined, a second version was built using a sheet of aluminium foil and a layer of foam rubber.

and, once its operating principle was understood, a first version was built using paper and aluminium foil. This version was tested for several consecutive days. Although robust and efficient, paper was not considered the best material for the final version of this pressure switch. Given that this sensor would be transported, assembled and disassembled several times and stepped on by users, acetate was chosen to replace the paper. This acetate version was used in presentations in London and Berlin and worked perfectly. However, before the presentation in Funchal, it was decided to redesign this switch again, implementing it with a combination of aluminium foil, acetate and vinyl to make it even more resistant. This power switch, connected to the microcontroller, which in turn was connected to the central processing unit, allows the generative algorithmic composition to be activated on the hyperinstrument in SoLu. It should be noted that the redesign of this switch responds to a hybrid issue that integrates functionality, ergonomics, technology and aesthetics.



Figure 35. Detail of the thickness of the switch in SoLu. André Rangel 2010.

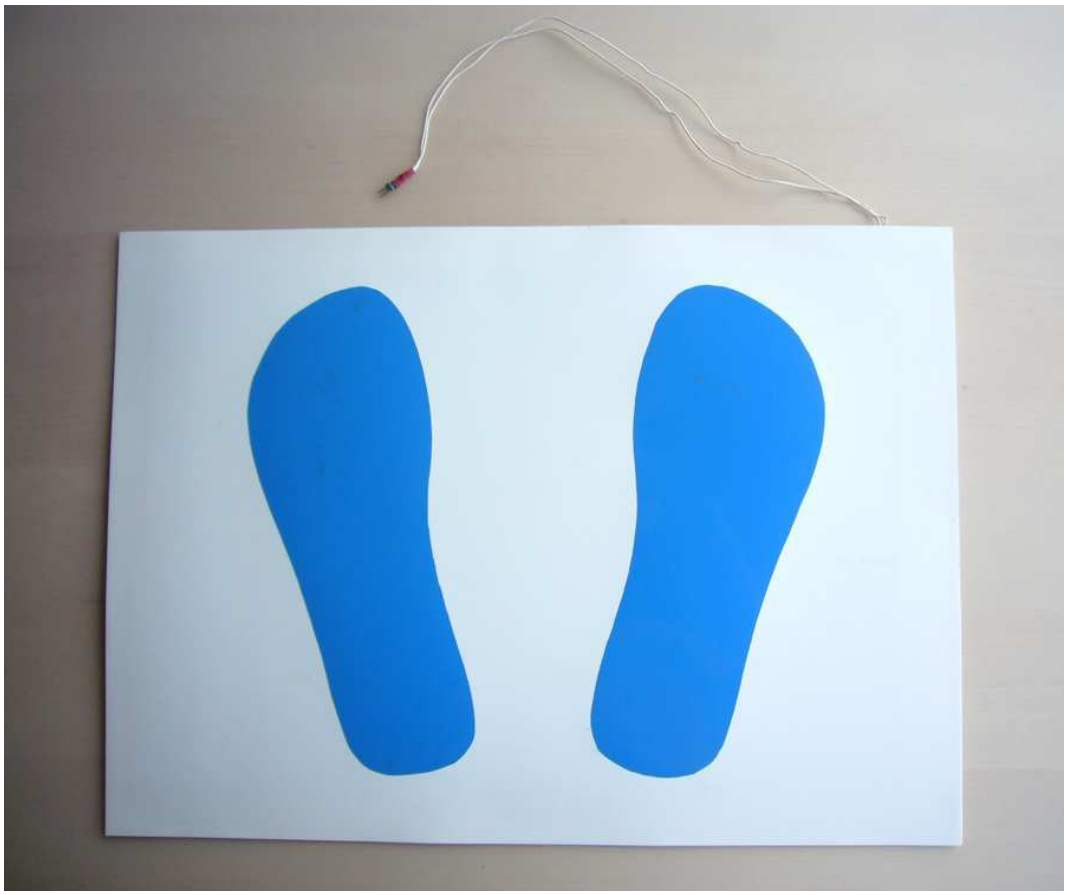

Figure 36. Switch in SoLu. André Rangel 2010.

GREENRAY AND SYNDYN

The works GreenRay and SynDyn are presented as concepts of urban aesthetics oriented towards the outside of conventional artistic circuits and theoretical artistic discourses. These are works that take place outside the spaces of the museum, gallery or studio, which exist in the relationship established with the places where they are presented, promoting an aesthetic approach to these same places. These works, to paraphrase Hawkins (2012), relate to geography; they are site-based artistic practices that are integrated into their social contexts. In these works, the social site, including its community, is the subject, material and audience of the works themselves.

GreenRay and SynDyn are spaces for sensory exploration, in which the presence of the body and its senses are indispensable to understanding the artistic experience, which, not limited to an intellectual act, is apprehended 'through the complex perception of the body as a whole' (Hawkins, 2010). As spaces of distributed agency, these intermedia works can easily be identified as what McCormak (2008) considers to be places for thinking about the relationships between bodies, concepts and materials of various kinds. As previously mentioned in this thesis, which affirms the equality of means, bodies, concepts and any material are means in the context of intermedia art and design. Thus, in the context of the reflective practical research developed in this PhD, McCormak's identification is updated, considering the works resulting from this research only as places to think about the relationship between media.

Even before developing the written rationale that explains the process of designing and developing GreenRay and SynDyn, it is appropriate to have a brief discussion in the next section about space in the context of these works, as they simultaneously result in space, model space and use space as a medium.

SPACE

The notion of space deserved in-depth study in the reflective practical research that resulted in the works presented in this dissertation. Sensible space is that which is apprehended with the senses. Spatial perception is an exploratory activity mediated by the sensory-motor apparatus of human beings. From an enactive perspective (Noë, 2002), spatial perception is an enactment resulting from the structural fusion of the organism with its environment. In particular, in the works GreenRay and SynDyn, this exploratory activity is precisely provoked, in which spatial properties are accessible to more than one sense (vision).

Because we have a body, we are spatially located beings and, when awake, we are always looking in some direction. Thus, space is always present; it is a constant in life. The way we perceive the spatial context around us is a fundamental part of our thinking and behaviour. GreenRay and SynDyn, as spatial arrangements, aim to simultaneously engage the audience's senses of sight, hearing and touch, affecting their choices and behaviours. Reflecting a desire for sensual pleasure, these works provide a configuration that envelops the audience, making them both the element and the fundamental medium of the artwork. The concept of the artistic object, explored in the development of these works, implants information in an environment, constituting a perceptible space modelled for the presence of the audience.

Still within the study of the notion of space, GreenRay and SynDyn, as works resulting from this research, appropriated and crossed knowledge from the fields of architecture and visual communication design, among others. The practices/theories of the figure-ground relationship were reused in the solid-void relationship, reaffirming that empty spaces, formed by the positioning of objects, are as important as or more important than the pro-

objects themselves; that three-dimensional spaces are considered positive spaces when they have a defined shape, giving a sense of delimitation; that positive spaces can be defined by an infinite number of elements such as points, lines, planes, or lighting; that spaces that are not explicit but apparent are considered implicit. In GreenRay, SoLu and SynDyn, the equality of 'empty' space and solid space is affirmed. In GreenRay in particular, positive and negative spaces are defined by objects: human bodies; points, at the intersections of laser beams; lines, which are the laser beams themselves; planes, defined by groups of coplanar laser beams; and also by volumes resulting from the interaction of these objects in space. For example, the volume below the laser carpet and the volume above it, or even the volume delimited by the laser beams.

It was interesting to note that human behaviour in GreenRay was heterogeneous. Some people preferred to place their bodies in front of the beams, altering the pattern of the tapestry, while others preferred to avoid the beams by walking only in the spaces delimited by them. It was noted that the latter people, despite being in front of laser beams, behaved as if they were wires. They affirmed that the space occupied and determined by the laser beams, their physicality and materiality, are perceived in the same way - with conviction - as solid volumes are perceived.

> Urban spaces are passages through which bodies, symbols and material things move. Some of them are more boundary-like than others, some even develop into extensive borders (Fornäs 2002).[396]

395 This practice is also evident in the works ColMus and SoLu.

396 Translation by the author from the original: 'Urban spaces are passages, through which material things, bodies and symbols move. Some of them have more of a threshold character than others do, some even grow into extensive borderlands.' (Fornäs, 2002)

GreenRay is an urban space, a threshold urban space, a space of passage, of transition between an exterior space and an interior space. The work was intentionally conceived as a place of passage and installed in the access area to the Lux nightclub building, so that anyone heading towards the entrance to the building was inevitably immersed in the space of the work, being immediately transformed into part of the work.

GREENRAY - TAPESTRY OF LIGHT



Figure 37. GreenRay. André Rangel 2009.

GreenRay [397] is a fabric — tapestry — of laser light, presented as an interactive intermedia work that combines sculpture, architecture, installation, sound and light. The 'loom' designed to weave the fabric of laser beams consists of two parallel mirrors placed vertically on the floor. Using green lasers with a wavelength of 532nm and the principle of multiple reflection, this work produces a flat visual weave parallel to the floor — 10cm above it — whose appearance is modified by movement.

397 http://3kta.net/3greenray.php

audience, who, challenged to participate in this collaborative artistic experience, becomes a co-creator of the work. For the audience, it is both an artistic experience and an intense physical activity. This intermedia work was born out of the desire to conceive and produce a totally analogue interactive work of art that did not use any kind of digital processing (computer), but which, at the same time, could be presented as a new optical and environmental configuration, as well as a landmark or reference point for post-digital contemporary art.



Figure 38. Audience participation in GreenRay. André Rangel 2009.

One of the objectives in the meta-design of this work was its easy and intuitive use by the audience, who can interact with the artistic composition by drawing different patterns and participating in the creation of an interface (with the human body and its movement) that does not require literacy. In GreenRay, there is a phenomenon of non-verbal communication (Mo-hammadi and Vinciarelli, 2010) in which the emotions, feelings, intentions and social attitudes of audience members are perceived by the rest.

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398 Alenxenberg (2011) defines the term post-digital: "Post-digital (adjective) Of or pertaining to art forms that address the humanisation of digital technologies through interplay between digital, biological, cultural, and spiritual systems, between cyberspace and real space, between embodied media and mixed reality in social and physical communication, between high tech and high touch experiences, between visual, haptic, auditory, and kinesthetic media experiences, between virtual and augmented reality, between roots and globalisation, between autoethnography and community narrative, and between web-enabled peer-produced wikiart and artworks created with alternative media through participation, interaction, and collaboration in which the role of the artist is redefined." (p. 10)

399 It should be noted that this objective of allowing the audience to participate in artistic composition is constant in the four works described in this thesis.

members through their facial expressions, gestures, and postures. As such, GreenRay is also a social laboratory that provokes socialisation.



Figure 39. Socialisation provoked in and by GreenRay. André Rangel 2009

By giving control to the audience, it becomes the performer of the artistic work responsible for finalising the concept. When the audience creates or (de)forms the content of the artwork, it transforms from receiver to main provider/emitter. As a process and as a discourse, GreenRay also investigates the relationship between the artist and their audience, proposing an informal configuration that encourages the audience to participate, interact and enjoy the work without being pressured by messages or ideological positions. By erasing the division and enhancing the connection between artist and audience, this work brings together, in an act of enaction, the dimensions of doing and experiencing the result of the deed.



Figure 40. Appearance of the work transformed by the audience. André Rangel 2009

The algorithm that integrates and is the work has as its input, as a variable, the position and movement of the body of each member of the audience, which ensures the indeterminacy of the result. But the movement of each member of the audience is also a result, therefore an output of the system. The work Gre-enRay is an interaction between human beings provoked by a provocative configuration of laser beams. Simultaneously, it is also the interaction of these same human beings with the set of laser beams. It is a hybrid interaction between media. Between human beings, as media; and between human beings and light beams, both considered media. Human beings and their gestures are the work. The light and its flow, controlled by human gestures, is the work. The light beams without the human beings and the human beings without the light beams do not make the work possible. In the Gre-enRay algorithm, the 'inputs' are 'outputs' and the 'outputs' are 'inputs'; they are hybrids of inputs and outputs. The laser beams are the result, *the output*, but at the same time they constitute the interface itself and therefore *the input* of the system, of the algorithm. It is an intermediate dynamic that transforms its means into hybrids.

Because vision and our very existence depend on light, the practical research that led to GreenRay focused mainly on technologies that allow us to transform the appearance of a space while respecting the existing architecture. Light is a medium that allows for such transformation. Thus, research was conducted on video projection, surfaces

and materials for video projection, conventional lighting, LED technology and laser technology for lighting and image projection. In addition to surveying the latest devices available on the market, this study involved more in-depth research into the physical properties of light and colour.

GENESIS

The idea for the GreenRay work arose almost 'accidentally'[401], on a summer night in 2009, while testing hypotheses for new optical configurations. One of these configurations was an idea for a system that combined a video projector with a continuously rotating motorised mirror, used in lighting robots called 'scanners'. Before moving forward with the implementation of the prototype system that would eventually become GreenRay, an experiment was conducted in which a CD (Compact Disc) was placed in front of the video projector lens as an alternative to the mirror to move the video projection.

Given the availability of some laser devices in the laboratory where part of this research was carried out, an intuitive experiment was also conducted involving shining a laser beam onto a CD. Curious visual patterns caused by the projection were immediately observed, in a

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400 Part of this study resulted in the proposal of a correspondence between light and sound presented earlier in this text.

401 Earlier in this text, serendipity was mentioned as an attribute of the process of intermediate synthesis. The genesis of the work GreenRay confirms this characteristic.

402 The idea was to dynamically move and direct the flow of light emitted by a video projector. Given that video projectors should not be moved while in operation, so as not to damage the lamp, the solution is to keep the projector fixed and create movement using a motorised mirror placed directly in front of the video projector lens. At the time of writing, this type of solution is already commercially available: http://www.artificialeyes.tv/vms/products/vmu

403 An example of a 'Scanner' is the 'T-Rex' model from Martin. It is a lighting device consisting of a 250-watt halogen lamp and a motorised mirror. The light hits the mirror and the movement of the mirror produces dynamic lighting effects in the air.
For details of this device, please refer to the specifications and/or manual at: http://www.martin.com/product/product.asp?product=t-rex

wall, from the combination of laser light reflected and diffracted by the CD[404]. Despite the temporary curiosity and enthusiasm aroused by the visual possibilities of these patterns, the division of the laser beam — into reflected light and scattered/diffracted light — and the consequent loss of brightness — because when the light beam is divided, each resulting beam shines with less intensity — led to the choice of a configuration that multiplied the beam instead of dividing it. The solution was to use two parallel flat mirrors. Without wishing to discuss the importance of the mirror in humanity and in particular in philosophy, art[405], mathematics and physics, it is fundamental in the post-digital context of this work to refer to the idea of multiplication allowed by the juxtaposition of at least two mirrors. It is not intended to discuss the phenomena of calculation or computation, but, in fact, the multiple specular reflection of the mirror presented itself as a powerful, efficient and instantaneous form of calculation and computation which, despite its simplicity and antiquity, surpasses the capacity of the most modern computing devices when performing the same task[406]. The possibility of computing without a computer, and of calculating automatically faster than a computer[407], presented itself as a contrasting hypothesis and one of great critical importance to today's highly computerised and digitalised society.

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404 A compact disc is an information storage system with a light-reflecting surface. This surface has several concentric microscopic grooves that disperse light. When a laser beam strikes the surface of the compact disc, part of the light is reflected and another part, being dispersed by two grooves, creates constructive interference of a diffraction pattern.
Theory of diffraction caused by a compact disc: http://physics.randolphcollege.edu/lab/106_116lab/Laser/CD.htm
Some exercises using this phenomenon: http://www.physics.smu.edu/kehoe/1301S06/cd_diff.pdf
http://ocw.mit.edu/high-school/labs/physics-electricity-and-magnetism-labs-from-8.02/8_02_spring_2007_experiment9.pdf http://www.physics.mun.ca/~p1051mm/lab6.pdf

405 Various artists use mirrors as a medium in their works, both as a way of integrating the audience and as a way of multiplying the image of reality. Among these various artists, we suggest consulting the works of Dan Graham, Jeppe Hein, Bojan-Sarcevic, Anish Kapoor, Ken Lum, Graham Caldwell, Olafur Eliasson, Joachim Sauter, or the United Visual Artists collective.

406 Consider the classic example of the kaleidoscope, invented in the early 19th century, which has been revisited and mimicked in various algorithms and computer programmes for the creation and investigation of patterns. The kaleidoscope generates patterns 'instantly' or at the speed of light. A computer, with the appropriate display devices, can generate similar patterns, but always at its processing speed.

407 In the specific case under study, the pattern generated by the combination of laser beam and mirrors is formed at the speed of light. A similar pattern displayed on a screen, calculated by a computer, would be formed more slowly, depending, among other factors, on the processing speed of the computer. This fact would only be contradicted if, hypothetically, there were computers operating at superluminal speeds.

While still in the laboratory, it was decided how the audience would participate and what level of control they would have. Once a small prototype had been built, consisting of two parallel flat mirrors and a green laser beam, it was decided that GreenRay users could participate and transform the work itself, using only their bodies as obstacles to the flow of the laser beams.

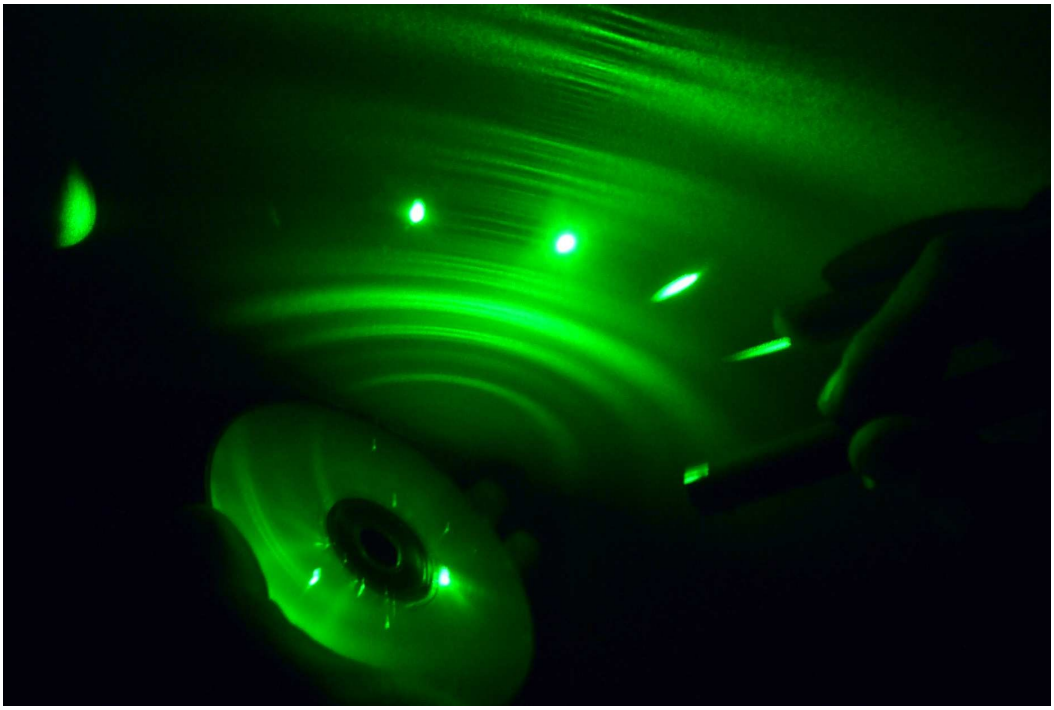

Figure 41. Laser light scattered and diffracted by CD. André Rangel 2009.

The phenomenon of multiple reflection was considered as a simple iterative multiplication process. In the context of the research that resulted in GreenRay, each iteration corresponds to the path of the reflected laser beam, according to the law of specular reflection, from one mirror to the opposite mirror. The interruption of the laser beam by a user is

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408 Iteration: The act or effect of iterating; repetition; doing again, repeating.
In mathematics, iteration refers to the act of performing any mathematical process—a computation, algorithm, or construction—on an initial value and then repeating the same process on the result. Each repetition of the process is an iteration of the process. For example, counting integers (0, 1, 2, 3, 4, ...) can be seen as an iteration of the operation 'add 1' with the initial value '0'.
Iteration appears in mathematics both in the simplest arithmetic operations (such as counting) and in more recent ideas about fractals and chaos. In academic curricula, iterative processes are present in arithmetic processes, calculations, fractals, art, design, geometry, statistics, among other disciplines. Iterative phenomena are also frequently observable in nature and studied by physics, chemistry, and biology. The repetitive nature of iteration makes it suitable for a range of production, creation, and problem-solving processes.

synonymous with interrupting the iteration of the multiplication process. By interrupting the laser beam, the user determines the 'multiplier' and consequently the visual pattern that is the product of the 'operation'. Theoretically, mathematical multiplication can be described as a way of adding a finite number of equal numbers. Conceptually and in practice, in the GreenRay prototype, the length of the mirrors is finite, so the number of reflections is also finite. Another type of multiplication — amplification — is the transition from the small-scale prototype to the full-scale installation of the work: a carpet of light 10 metres wide by 20 metres long. The realisation of the phenomenon of specular reflection in the full-scale GreenRay installation — 10m x 20m — raised a series of challenges/constraints that will be described in the following sections.

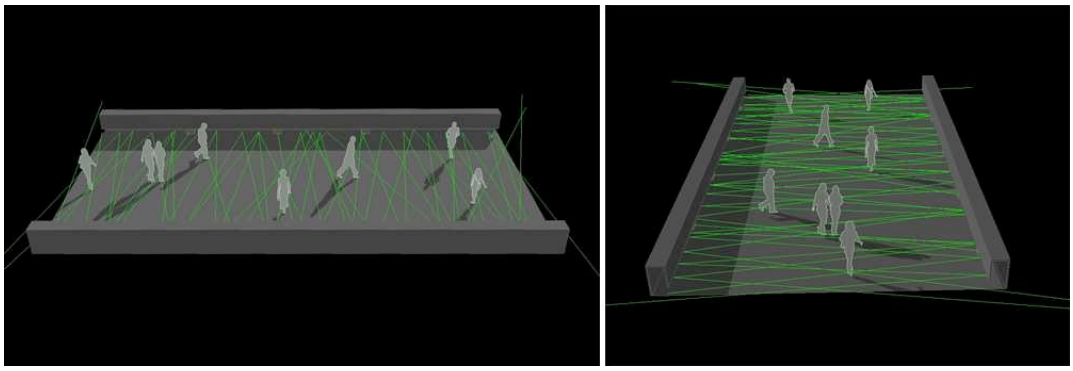

Figure 42. Models for the STRP festival. André Rangel 2010.

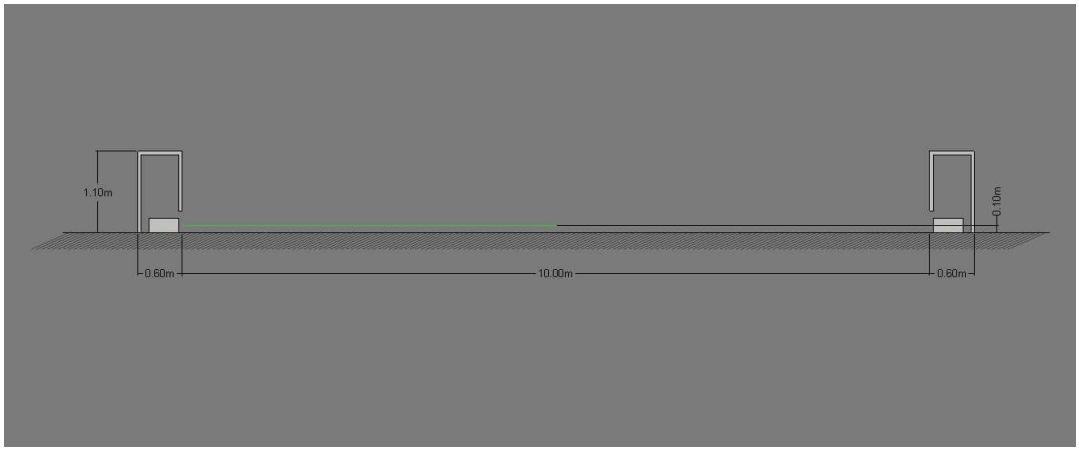

Figure 43. Technical drawing for the Digital Graffiti festival. André Rangel 2010.

LASER VISIBILITY

Although light, as an electromagnetic phenomenon, can propagate in a vacuum, for a beam of light — a laser — to be visible, matter is needed, for example particles in the atmosphere that reflect it. The first presentation of the work GreenRay took place at Cais da Pedra, in front of the Lux Frágil nightclub, next to Santa Apolónia station, on 22 September 2009.

As this is a riverside area on the banks of the River Tagus, and given the annual statistics on humidity levels in [the area], it was considered that night-time humidity (fog) would be sufficient to reflect the laser beams and make them visible. However, a week before the installation of the work, weather forecast models indicated, against all statistical probabilities, low cloud cover of less than 5% for the night on which the presentation of the work was scheduled. In other words, by 'coincidence', it seemed to be the driest night of the year, when humidity and fog were necessary for the success and visibility of the work, so that the lines of light from the laser beams would be clearly visible and defined. Therefore, bearing in mind Murphy's [Law] 410, knowing the statistics and aware that the forecast could be wrong, it was decided to ensure an alternative solution in case low cloud cover was confirmed on the night of the presentation. The solution was to consider using two *haze* machines and two fans (to spread the smoke) to maintain artificial cloud cover that was as homogeneous as possible. The weather forecasts confirmed

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409 According to statistical maps, in September the average humidity is around 67%http://www.theweathernetwork.com/statistics/c03468/POXX0016

410 'Anything that can go wrong will go wrong' (Edward Aloysius Murphy cited in Spark, 2006). Author's translation: 'Anything that can go wrong will go wrong'.

411 *Hase* is the name given to a type of smoke machine. There are smoke machines and *haze* machines. At GreenRay, we opted for *hase*, as the fluid used to produce the smoke is oil-based, which means it dissipates more slowly. The smoke produced by smoke machines is made with a fluid that contains water. Although it is denser than *hase*, it dissipates more quickly.

They settled and it was even necessary to use the alternative of producing artificial cloudiness. Although maintaining relative homogeneity in smoke density is an extremely difficult exercise in an outdoor environment subject to atmospheric imponderables such as breeze, the result was assured. All small variations in smoke density were assumed to be a plastic and aesthetic attribute.



Figure 44. Effect of smoke density variation. André Rangel 2009.

As this is a work created with light, its visual impact is enhanced by a darkened surrounding environment. The location where the GreenRay work took place is adjacent to the Port of Lisbon, where, as a rule and for safety reasons, there are very powerful lights (see image). The success of the presentation of the work also depended on the deactivation of these lights, which are the responsibility of the Lisbon port authorities. The authorisation and action to keep the two lights off during the night of the GreenRay presentation was the result of a laborious negotiation process.

FROM PROTOTYPE TO FULL SIZE

Another major constraint — which, in the context of the reflective practical research carried out in this doctoral thesis, is seen as a challenge — In implementing this project, the small-scale prototype was expanded to install the full-scale project. The prototype was initially built in the laboratory using a 532 nm, 150 mW class IIIb[412] green laser. Although this class of laser can cause eye damage if pointed directly at the eyes, it was considered that this risk would be minimised by placing the laser beam horizontally, 10 cm above the floor. With two 42 x 5 cm mirrors placed parallel to each other, facing each other at a distance of 21 cm, causing the laser to strike one of the mirrors at an angle of 80º, the phenomenon of multiple reflection was efficient, with the first 12 reflections of the beam having sufficient visibility and brightness for the desired aesthetic result. However, the enlargement of the installation to full size, with an area more than 2000 times larger than the area in the prototype[413], raised a new challenge: the distance travelled by each laser beam between each reflection was about 50 times greater. This greater distance to be travelled by the laser beams, combined with the fact that the 'fog' reduces the penetration depth of the laser[414] and that the brightness of the laser beam is considerably reduced after each reflection (despite low-absorption flat mirrors were considered), led to one of the major technical challenges of this project: the choice and assembly of the laser modules.[415]

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412 For summary information on laser class definitions, please refer to the website: http://www.stanford.edu/dept/EHS/prod/researchlab/radlaser/laser/procedures/classes.html

413 The prototype measuring 0.42 x 0.21 metres occupies an area of 0.0882 m^2, while the actual installation measuring 20 x 10 m occupies an area of 200 m^2.

414 In the specific case of the GreenRay installation, the mist would be natural humidity, but in the absence of this, artificial mist produced by a *haze* machine was used.

415 '[...]high surface waves and heavy fog decrease the depth penetration of the lasers.' (Stolt & Rebenhorst, 2011)

A need to balance constraints was identified. The 'fog' was necessary for good laser visibility but simultaneously reduced its power along the beam path. Using more powerful laser projectors increases the distance travelled and visibility of the laser in the 'fog' but also increases the risks to users. The GreenRay assembly is the result of a balance between the visibility and aesthetic power of the work and the limits of user safety and legality.

Initially, the use of a larger number of low-power laser modules was considered, around 30 modules of up to 20 mW[416], but after several considerations regarding the fixing of the lasers, their positioning and alignment, so that all beams were coplanar, and the fact that it was an outdoor installation dependent on atmospheric conditions, it was decided to use fewer modules but with higher power. After observation and research on typical outdoor laser assemblies, it was found that the minimum power required for GreenRay to be realised would be 5 W, class IV[417], which led to the installation of lasers at a totally unforeseen logistical level in terms of safety, law and cost.

Given that the GreenRay work consisted of the audience interacting with the laser tapestry, more specifically, the interruption of the laser beams by the audience, and given the date on which the installation would be presented (September 2009), at the end of summer, when many people wear shorts or mini skirts with their legs exposed, for example, because

416 The first laser module considered for the installation was the following: GMP- Series 532 nm DPSS Green Laser Modules http://www.lasermate.com/GMP.html

417 Class IV is the highest and most dangerous category of lasers. Lasers in this category can cause skin burns and irreversible damage to the eyes.

safety standards [418], an optical configuration was chosen that would reduce the power of the laser beams. The solution involved dividing each beam into beams of lower intensity. This solution had a dual function: it simultaneously divided and multiplied each beam. Using an optical device called a *grating beam* splitter, each beam was divided into 14 beams, i.e. the number of visible beams was multiplied and the power of each laser was divided before it hit the users or mirrors. Without considering the amount of light absorbed by the splitter itself, each of the 14 beams resulting from the division had a maximum of 355 mW. Thus, although still a very dangerous laser power for the eyes, each of the visible beams in the installation could no longer cause damage to the users' skin. On a practical level, the option of using more powerful lasers proved to be very functional and advantageous, as only eight 5W laser devices needed to be aligned for the installation, instead of the 30 20 mW modules initially planned. However, on a logistical level, the use of these top-of-the-range lasers raised a number of other challenges. Firstly, in Portugal, the use of laser devices with a power of more than 5mW by private individuals is prohibited, and the lasers used in GreenRay are 1000 times more powerful, so it was necessary to hire a specialised company authorised to operate this type of laser. Secondly, in GreenRay, the laser beams also shine on the users' bodies — legs — a technique known in professional circles as *Audience Scanning*, which is prohibited in some countries such as the United States.

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418 As a matter of interest, with a 5W laser it is possible to easily light a cigarette or cut a plastic bottle. By way of comparison, a class IIIa or 3a laser found in many laser pointers and key rings has a maximum power of 5mW. The lasers used in Greenray light tapestries are 5W, making them 5000 times more powerful. Their use requires special legal authorisations in accordance with the laws in force in different countries.

419 Technical information on laser beam division can be found at:
http://www.optometrics.com/Products/products_beam_splitters.html#Transmission%20Grating%20Beamsplitters

420 Decree-Law No. 163/2002 establishes 5mW as the maximum laser power for commercialisation and/or private use.

421 Definition of 'Audience Scanning' according to Wikipedia: http://en.wikipedia.org/wiki/Audience_scanning

dos[422] or Sweden[423]. Because Portuguese law is silent on the projection of lasers onto people for recreational purposes, it was considered that there was no illegality. After researching companies that could safely rent and operate the type of laser needed to materialise Green Ray, a Belgian company was chosen because there was no company in the Iberian Peninsula that had the technical and human resources to guarantee the success and safety of the installation. In the presentation of the Green Ray work, eight 5W[424] laser modules were used, divided into 14 beams each, resulting in 112 visible beams before multiple reflection in the mirrors.

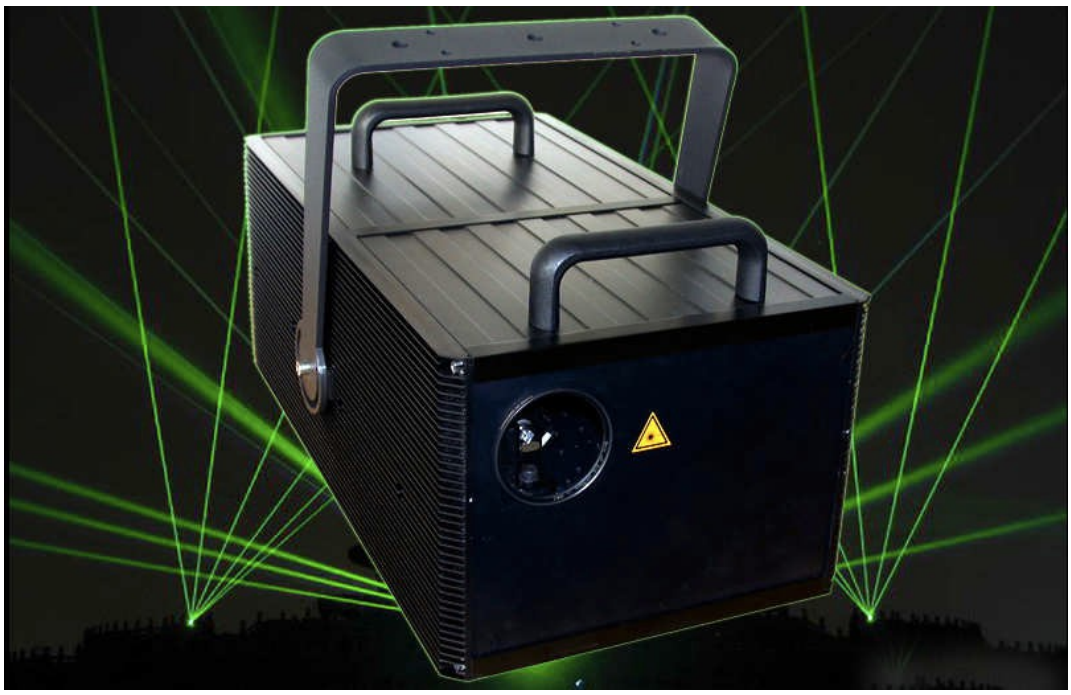

Figure 45. Blitz Pro 5 532 nm used in Green Ray. Laseranimation.com 2009.

422 Following an invitation from Kelly Arnold, one of the organisers of the digitalgraffiti.com festival, to present the GreenRay installation in Miami in 2010, companies that could rent the necessary laser devices were contacted. Ironically, in one of the telephone conversations with Tom Harman, president of LASERNET, Harman said something like: 'Everything that is illegal to do with lasers in the United States is in the GreenRay installation.' According to Illinois state law, lasers above class II can only be installed 3 metres above the highest point of public access: "Laser radiation levels shall not exceed the limits of a Class 2 laser at any point less than 3 metres above any surface upon which any individual in the audience is permitted to stand, and 2.5 metres in lateral separation from any position where an individual in the audience is permitted, unless physical barriers are present that prevent human access to these levels." in: http://www.ilga.gov/commission/jcar/admincode/032/032003150001400R.html

423 Consulting an article by Benner (2001) on laser safety projected onto the audience was fundamental to understanding the feasibility of the GreenRay project.

424 The laser projector used was the Blitz Pro, whose technical specifications can be found at: http://www.lasyseurope.com/uploads/fiches/Laser/BLITZ%20Pro.pdf

SYNDYN

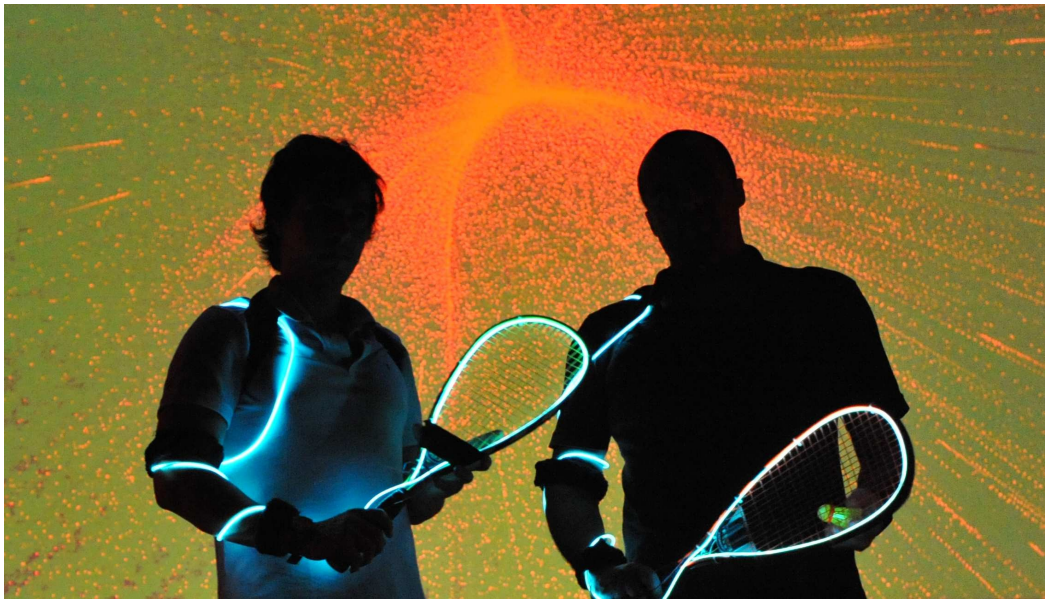

Figure 46. Presentation of the work SynDyn at the Portuguese Catholic University. Photograph by Luis Maruta 2011.

Another result of the reflective practical research carried out during this PhD was the implementation of the *SynDyn*[425] concept. Etymologically, *SynDyn* is a contraction of the Greek words 'syn', meaning 'together', and 'dyn', also from Greek, meaning 'dynamikos', or powerful, which is also associated with the term dynamics. *SynDyn* combines aesthetics, physical activity and public entertainment. *SynDyn* transforms any existing sporting activity into an instrument of audiovisual expression. From football to climbing, from table tennis to windsurfing, with the appropriate configuration, sport can be aesthetically expanded and enhanced by *SynDyn*. This original concept has received several references and comments at an international level. This work can be considered the most ambitious development in this PhD, both in terms of its importance and international impact, as well as in terms of all the logistics involved in its materialisation, documentation and publication.

425 http://syndyn.net

In the first implementation of the concept, a racket sport was transformed into an event in which the participants, while engaging in vigorous physical activity, control all the audiovisual events that occur in the space-time of the game. The participants become performers in an audiovisual show. The work can be perceived as a game, but in fact, it is an autotelic[426] activity, where there are no scores, winners or losers.



Figure 47. Presentation of SynDyn at Casa da Música in Porto. Photograph by Luis Maruta 2011.

The space where the event takes place is coloured with light that is controlled by the players' movements. Their arms and rackets are decorated with electroluminescent wire and the steering wheel with an LED[427], providing

426 Intrinsically motivated activity. See note on 'flow' in the section 'The flow of doing research through play'. We suggest consulting the work 'The Concept of Flow' (Csikszentmihalyi & Nakamura, 2002).

427 It is worth noting the exploration carried out to attach each LED to a small battery in a robust but flexible manner. Some of the moments of this exploration are documented in the figure.

vivid and dynamic scenic effects. At the beginning of each 'game', users choose a soundscape associated with colours and generative visuals for the ambient lighting system on an iOS device.

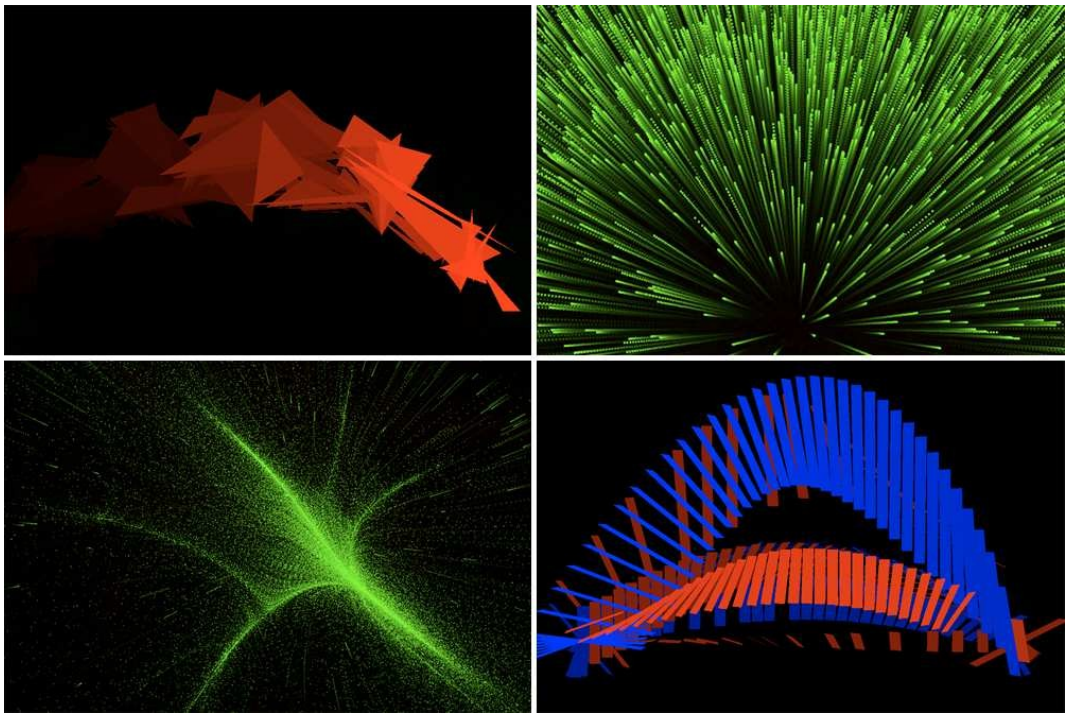

Figure 48. Examples of images calculated in real time, triggered by the impact of the shuttlecock on the rackets. André Rangel 2011.

In *SynDyn*, the rackets are equipped with sensors that detect each hit of the shuttlecock on the net. A radio transmitter transmits the data from the sensors on the rackets to a central processing unit — a computer. The hits on the rackets are accompanied synchronously by synthesised sounds and/or sounds reproduced in real time; by an instantaneous change in the colour of the ambient light, according to each user's previous choices; and by visual events, presented in video projection, also generated in real time.

428 The practical research in this PhD also included the design and development of an application and its graphical interface to operate on mobile devices such as the iOS system — iPod touch, iPhone, and iPad.



Figure 49. Diagram of communication between *hardware*. André Rangel 2011.

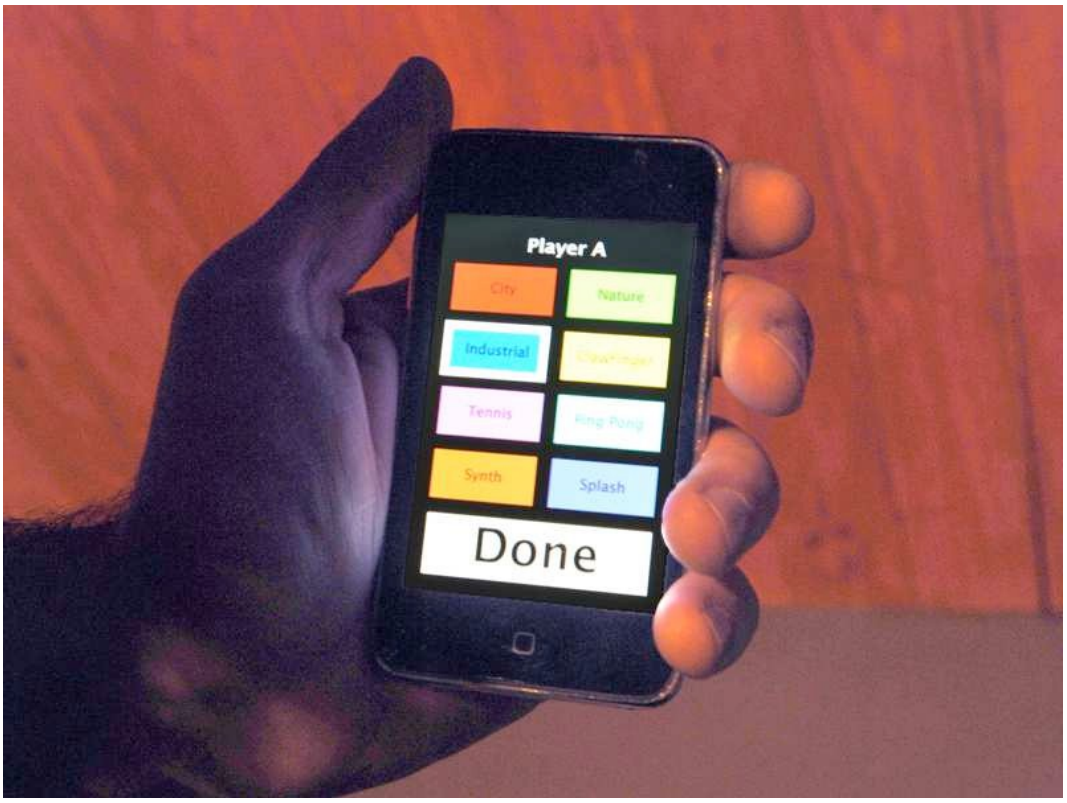

Figure 50. Graphical interface on the iOS device for choosing sound and visual landscapes. André Rangel 2011.

On the iOS device, a first menu with two options was designed. The first option accesses a menu with four buttons that configure four completely synthetic audiovisual landscapes. These landscapes are generated based on generative design principles, using particle generators.

cues and attractors in the visual domain and oscillators and digital noise generators in the sound domain. In the second option, a menu is accessed where each participant can choose a soundscape. This menu consists of eight rectangles of eight different colours, overlaid with eight words suggestive of the corresponding soundscapes: red — city; green — nature; blue — industrial; yellow — *clawfinger*; magenta — tennis; cyan blue — ping-pong; orange — synthesiser; and purple — splash (water). For example, if player *A* chooses the 'green — nature' rectangle and player *B* chooses the 'red' rectangle
— city', automatically, the soundscape of the location where *SynDyn* takes place is filled with a sound composition that mixes sounds that can be heard in a city — engine noises, people talking, sirens — and sounds that can be heard in nature — birds chirping, wind and vegetation. In this configuration, each stroke of the racket by player A is accentuated by a city sound — car horns, sudden braking, among others — which stands out from the rest of the soundscape, while the space is coloured with red light; and each stroke of the shuttlecock on player B's racket is accentuated by a sound from nature — the breaking of a branch, the chirping of a bird, among others — and simultaneously the space is coloured with green light. For each soundscape, there is a bank of dozens of sound samples that are randomly chosen by the system at the moment of each stroke on the racket.

In addition to the real-time audiovisual response described above, users can also obtain a visual memory of their performance. A camera, controlled by the same central processing unit, covers the entire event area and takes long-exposure photographs. This camera records the trails representing the trajectories of the luminous wheel, and the illuminated rackets and arms. In this way, the longevity and memory of an ephemeral work is ensured. Literally, the possibility of drawing with this work gives *SynDyn* its original and innovative character

: it is simultaneously a sport, entertainment and artistic event that blends aesthetics, physical activity, technology and entertainment. This work exists as a hybrid between installation and performance.

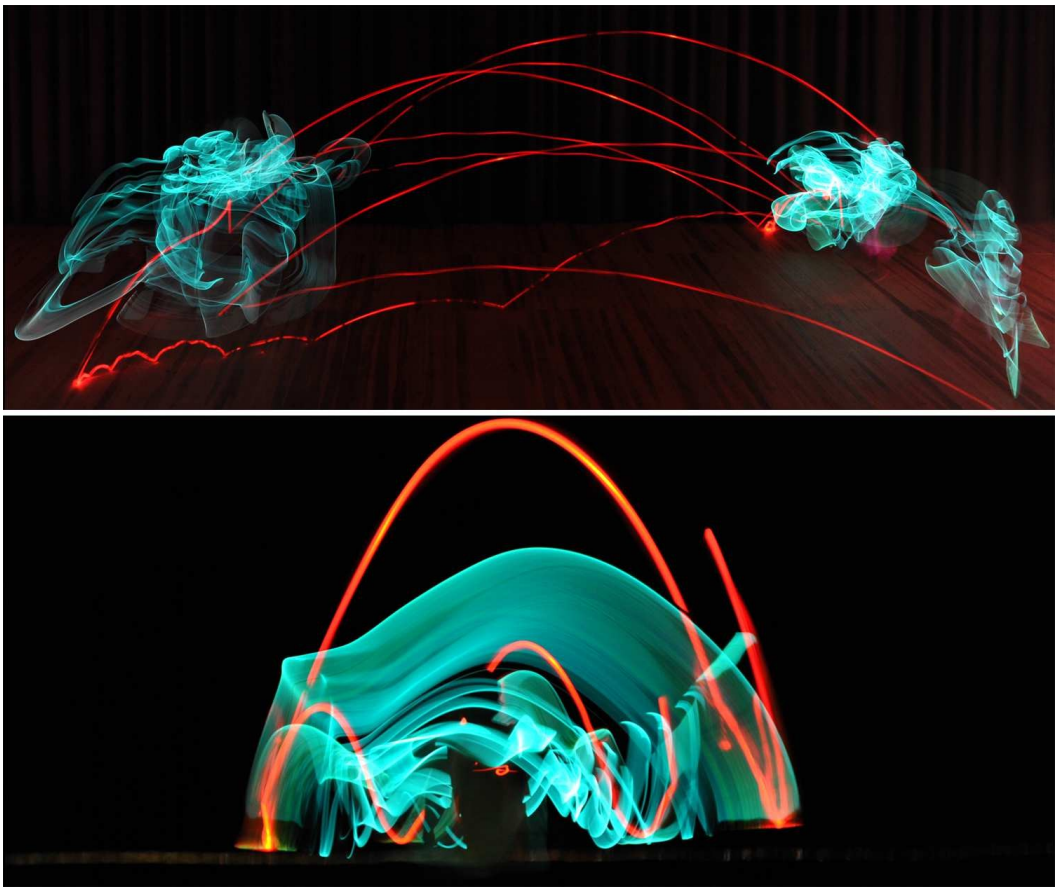

Figure 51. Light drawings in SynDyn. Photograph by Luis Maruta 2011.

At *SynDyn*, the urban, free and rebellious spirit is enhanced by a youthful and aggressive image, which, associated with the idea of speed, power control and precision, seeks to attract urban tribes who play/game in unconventional places. *SynDyn* allows the appropriation of entertainment venues in the city, emphasising concepts underlying the practice of sport — audacity, freedom and rebellion (parkour/graffiti) — in the sense of adapting conventional sports to the urban context of the city, taking advantage of its equipment, obstacles and architecture. It is a 'clean' sport that does not require special infrastructure and has no permanent negative impact on the landscape, a factor that

denigrates the image of extreme urban sports. In this sense, *SynDyn* is an urban experience that uses urban infrastructure as a backdrop and citizens as performers and spectators, thus pointing to future possibilities for the city and for urban sports.

The *SynDyn* work increases the space where it occurs — allowing for unique interaction with the surrounding landscape — participants in the event control changes in the colour of the light in that space as well as its landscape [sono-ra429]. *SynDyn* aims to be a spatial project that, in an urban context, can take the form of street art, public art, mixing technology, digital media and [community430]. *SynDyn* aims to encourage the reuse of urban, rural or natural spaces, temporarily giving them a new function: to be simultaneously places for artistic and sporting practice and exhibition.

By transforming the lighting conditions and soundscape of the location where it occurs, *SynDyn*, as a performance, undoubtedly interacts with and affects the perception of the infrastructure and physical form of the location, without damaging it. Light is essential for vision, and *SynDyn* strongly affects the quality of light where it occurs, so the visual impact is very strong. In order to ensure low energy consumption, *SynDyn* uses LED lights that consume much less electricity than traditional incandescent lights.

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429 It should be noted that in addition to the sounds being synthesised in real time, the landscape and sound textures are also constructed by algorithms designed and programmed exclusively for the work. In SynDyn, users have the opportunity to construct the soundscapes of the event, manipulating them with their physical movements and gestures.

430 In the two presentations of the work, to demonstrate the system, tennis players from local tennis clubs were invited.

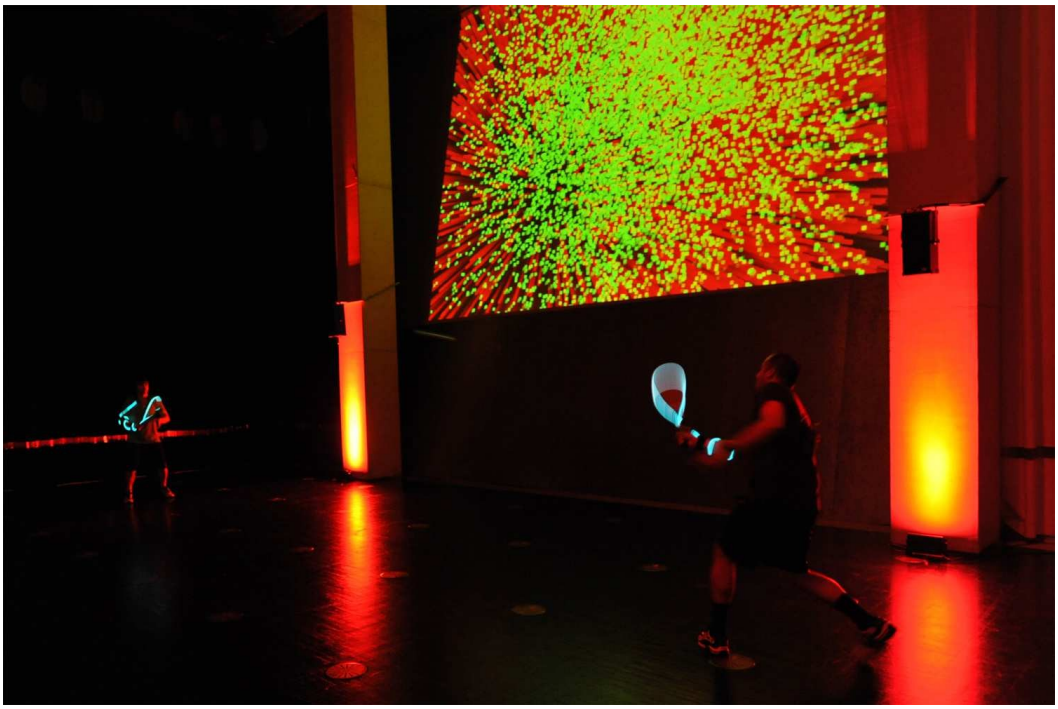

Figure 52. Use of urban infrastructure. Photograph by Luis Maruta 2011.

DMX AND RADIO

As mentioned above, light and lighting are fundamental to the perception of any space. Their design and control make it possible to transform the appearance of certain spatial and architectural contexts. For the development of an interactive intermedia work, in which, in addition to sound (and visual) events, lighting can also be controlled by user action, communication protocols were investigated that allow real-time control of lighting devices. Two main protocols were identified: the X10[431] language, which is more oriented towards home automation and domestic applications, and the DMX[432] protocol, which is used professionally in the entertainment world.

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431 http://en.wikipedia.org/wiki/X10_ (industry standard)

432 DMX or DMX512 — *Digital Multiplex* — is a communication protocol that allows remote control of various lighting-related devices, from motorised luminaires to smoke machines.
http://en.wikipedia.org/wiki/DMX512

The choice of one of these two communication protocols was based on the speed of operation of each. Thus, given that the DMX protocol operates at 250 kbaud[433] and the X10 protocol operates at only 20 bps[434], the faster one was chosen without hesitation: the DMX protocol. Box (2010) considers that anyone wishing to develop work with lighting technology should familiarise themselves with the DMX protocol. After choosing the protocol to be used, part of the practical research carried out in this PhD focused on studying the syntax of the DMX protocol.

In order to design the lighting system and computer programme that integrates the *SynDyn* work, two interfaces were tested and programmed, allowing connection between a computer and a lighting network composed of devices capable of executing DMX commands. The Enttec DMX USB PRO[435] and Lanbox LCX[436] interfaces were used in this phase of the research. Based on the experimentation and testing of these two interfaces, it was decided to integrate the Lanbox LCX interface into the *SynDyn* work, as it is more robust and also more versatile, allowing connections in various MIDI, USB or Ethernet formats.

Once decisions had been made regarding the communication protocol for controlling the lighting devices and the interface for connecting a computer to these devices, it became possible to design a computer programme that receives data on the number of times the ball is hit with the rackets, processes this data and transforms it into DMX commands, which are sent to the Lanbox LCX interface, which in turn sends them to the lighting devices. The robustness and efficiency were tested in the laboratory

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433 250 kbaud = 250,000 symbols per second. For more information on *baud rate*, please visit: http://en.wikipedia.org/wiki/Baud and http://en.wikipedia.org/wiki/Symbol_rate

434 20 bps = 20 *bits* per second. For bit rate, we suggest consulting the address: http://en.wikipedia.org/wiki/Bit_rate

435 http://www.enttec.com/?main_menu=Products&pn=70304

436 http://www.lanbox.com/lcx.php

of this programme so that, as a module, it could be integrated into the programme that ensures the interactivity of the *SynDyn* work, i.e., collection of data from the world outside the computer, visual generative synthesis, sound synthesis, and lighting commands.



Figure 53. DMX-512 LanBox LCX interface. Lanbox.com 2011.

Still related to communication protocols and audience interaction, whose participation in the work is achieved through the body and its movement, *SynDyn* aimed to give users the greatest possible freedom of movement. To this end, the sensor placed on the racket could not send the digitised data relating to the ball hits on the racket to the central processing unit via cable. A data transmission cable between each user and the central processing unit would be a major constraint on the free movements and gestures of users, so a wireless system was chosen to ensure the transmission of data from the sensors in the rackets to the central processing unit. In the initial design phase of the response to this challenge

challenge, the use of one of the following systems was considered as a hypothesis: the *Wi-microSystem437* system and the *Eobody2 HF438* system.

Although these two systems are easy to configure, their high cost led to the decision to build a wireless communication system for this research. After studying the existing possibilities, it was decided to build a radio communication system that would ensure data transmission between each participant's racket and the central processing unit. This system consists of a piezoelectric ceramic sensor, which detects the impact of the shuttlecock on the racket, connected to an *Arduino* microcontroller, which digitises the sensor data. the microcontroller is connected to an *XBee439* radio that transmits the digitised data to the central processing unit, to which a radio receiver is also connected.

In order to operate the XBee radio and the Arduino microcontroller, it was necessary to study the syntax and structure of the AT440 command language and the Arduino language, respectively. After learning these languages, it was possible to design and implement the programmes that ensure the radio transmission of data from the sensors in the rackets.

LUMINOUS STEERING WHEEL

In order to obtain a luminous steering wheel that could be simultaneously visible in a darkened environment and act as a drawing medium for long exposure photographs, it was necessary to design a customised solution,

437 http://infusionsystems.com/catalog/product_info.php/products_id/98

438 http://www.eowave.com/products.php?prod=57

439 https://www.sparkfun.com/products/11215

440 http://en.wikibooks.org/wiki/Serial_Programming/Modems_and_AT_Commands#What_are_AT_Commands.3F

441 http://arduino.cc/en/Reference/HomePage

in which a light source was inserted inside the steering wheel. In the initial phase of practical research into the design of this component of the *SynDyn* work, fluorescent substances were considered, but it was quickly realised that the light emitted by these substances would not be sufficient for the desired effect.

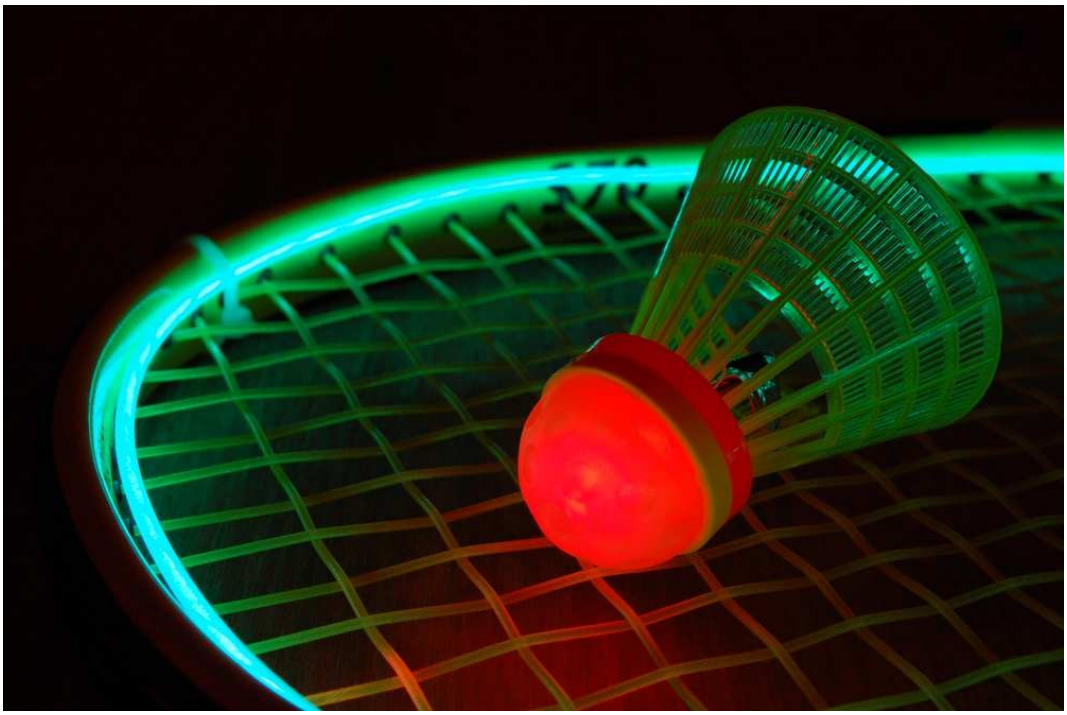

Figure 54. Luminous steering wheel. André Rangel 2011.

In the search for high-brightness light sources small enough to fit inside the shuttlecock, LEDs were found to meet the necessary requirements for the implementation of the luminous shuttlecock. However, LEDs require a power source that would also have to be integrated into the shuttlecock. Thus, practical reflective research was carried out with a view to integrating an LED and a small lithium battery into a badminton shuttlecock. The first step towards achieving the desired result was to drill a hole in the base of the shuttlecock, exactly in its centre. This hole has a diameter that allows the LED to be inserted under pressure. The precision of this hole is essential to ensure that the LED does not come out of place with the strong impact on the rackets' nets

and also to keep the shuttlecock balanced and stable during flight.

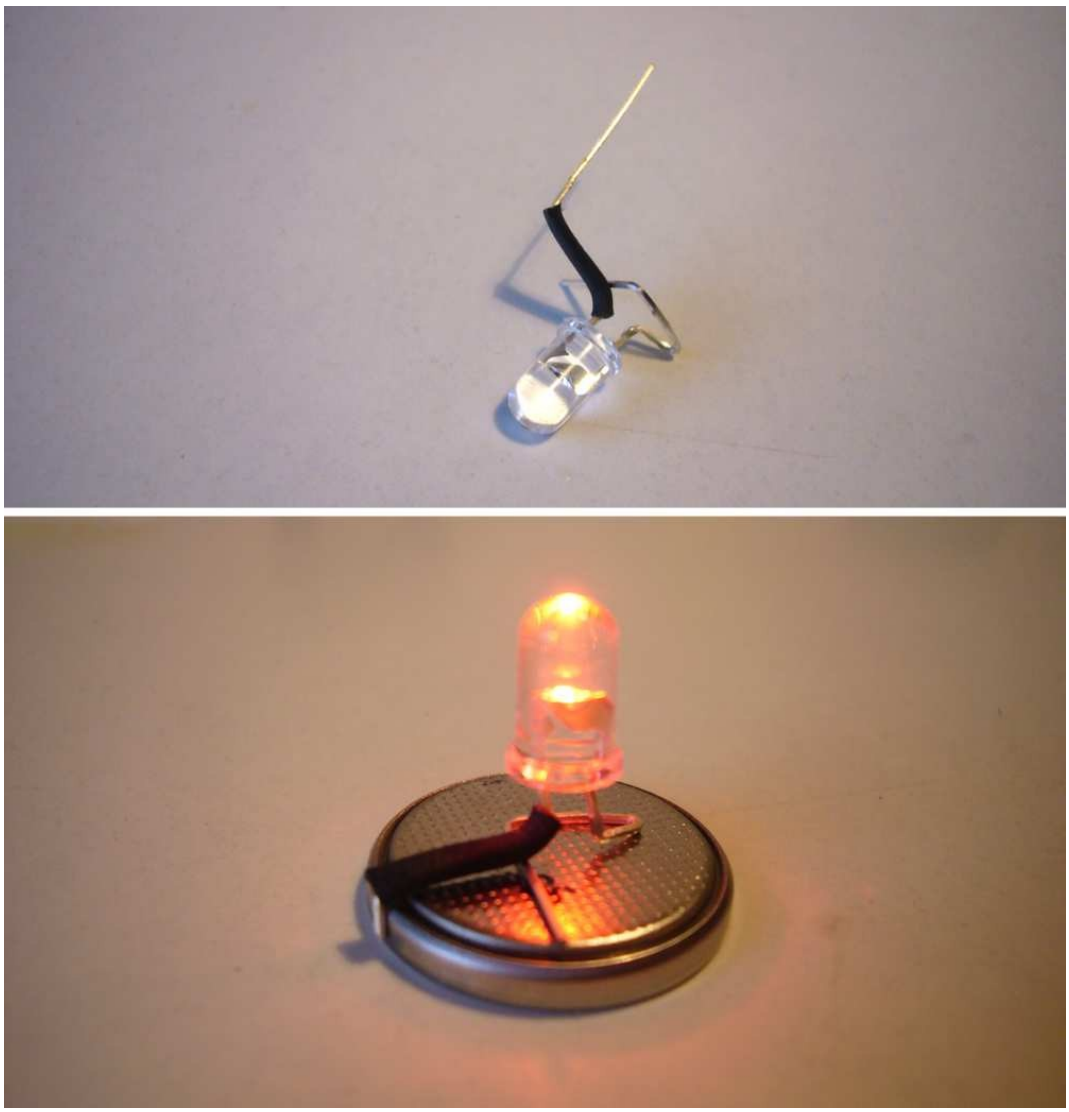

Figure 55. Bending the cathode and anode to secure the battery. André Rangel 2011.

The next challenge was to solve the problem of attaching the LED to a 3V lithium battery. In order not to add too much weight to the steering wheel, early experiments to solve this challenge determined that the system should be constructed with as few materials as possible. Thus, after a tacit dialogue with the LED and the battery, a hypothesis was constructed in which, through a folding process, the cathode and anode of the LED would function as a spring that secures the battery. This solution can

It may have been inspired by the tacit knowledge of how to use the classic cli-pe. In this approach, the disc-shaped battery is placed parallel to the base of the steering wheel. Given that the LED cathode is shorter than the anode, the LED is mounted orthogonally to the base of the battery, touching its negative polarity side. In this way, it was possible to bend the anode so that it would wrap around the battery to its positive polarity side. The battery is fixed under pressure between the cathode and the anode of the LED. Given that the anode has to travel the distance of the battery radius, pressed against the negative polarity side, a segment of heat-shrinkable sleeve was used to prevent contact, as illustrated in Figure 55.

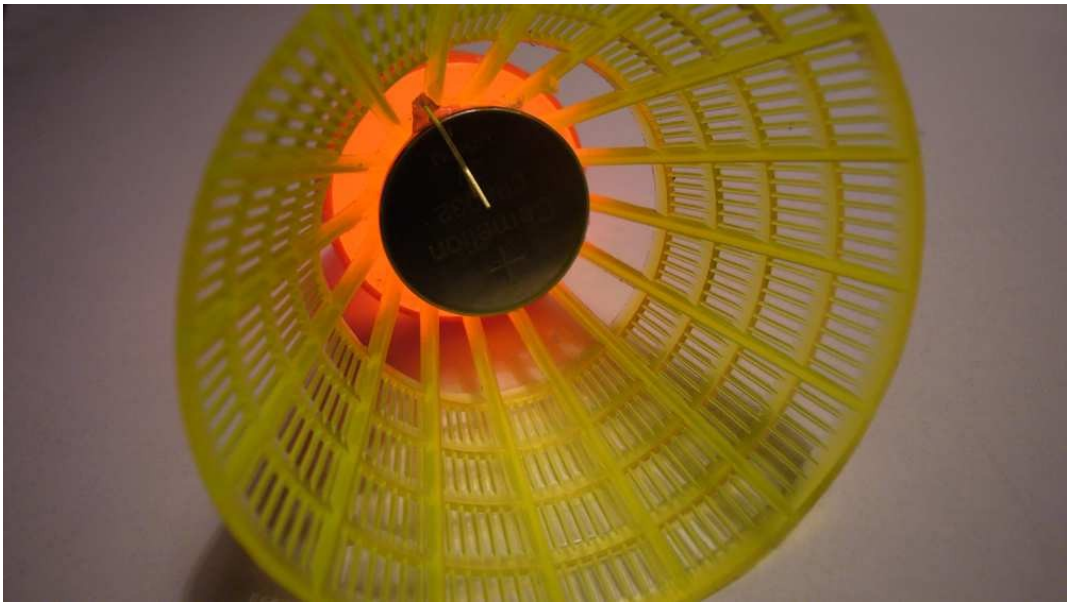

Figure 56. First fixing system. André Rangel 2011.

Although this solution added very little weight to the steering wheel, it did not have the necessary robustness to withstand all the stress caused by the strong impacts of each blow of the steering wheel on the racket, as well as the vibrations resulting from this action. After several tests, it was found that with this system, after about 3 to 4 minutes of intense use, the elastic stress limit [442] of the metal of which the cathode and anode are composed was exceeded and one of two situations occurred: either one of these elements broke, causing

442 http://pt.wikipedia.org/wiki/Limite_elástico

establishing contact between the two poles of the battery; or the cathode and anode ceased to exert sufficient pressure on both sides of the battery to maintain contact. This happens because when the tension applied to the material (of which the cathode and anode are composed) stresses it in its elastic domain, it always returns to its initial state — shape — but once the elastic limit tension point is exceeded, the material is stressed in its plastic domain and does not return to its initial state, i.e. it deforms or breaks.

Reflective practical research was carried out to develop a system that could mitigate the tension exerted on the cathode and anode or alter the elastic limit of the material of which these elements are composed. Given the success of *LED Throwies*[443], a similar configuration was considered for the LED-to-battery attachment system. In this configuration, the battery is wedged between the cathode and anode of the LED, without any folding. Adhesive tape is used to secure the LED to the battery. The *LED Throwies* system is not robust enough to withstand the stresses caused by impacts on the rackets. Therefore, a solution was developed that transforms *LED Throwies* into a much more resistant system.



Figure 57. Means of the second LED-battery fixing system. André Rangel 2011.

443 http://www.instructables.com/id/LED-Throwies/

This transformation consisted, first, of reducing the distance between the battery and the flat face of the LED, so that the cathode and anode were in contact with the battery along their entire length. Otherwise, the battery would act as a pendulum, increasing the mechanical stress on the cathode and anode. Secondly, the adhesive tape was replaced by a section of rubber sleeve that fulfils several functions: it absorbs part of the vibrations and tension, exerts pressure on the cathode and anode against the battery, acting as a fastener, and simultaneously protects the entire assembly. To ensure greater robustness of the system and because the rubber sleeve did not exert pressure on the first few millimetres of the cathode and anode, in the area near the LED head, this area was filled with a thermoelastic adhesive that performs the same functions as the rubber sleeve, acting as an extension of it. Given its efficiency and robustness, the solution described above was chosen to be integrated into the *SynDyn* project.

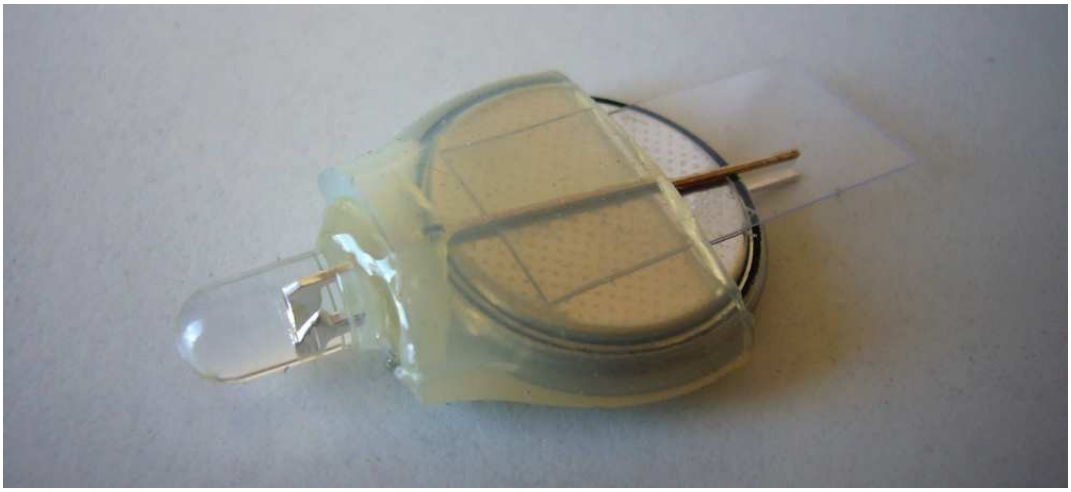

Figure 58. Second LED-battery fixing system. André Rangel 2011.

The assembly process for this system comprises a sequence of three actions: the LED is inserted into the rubber sleeve under high pressure, then the cathode and anode are inserted between the rubber and the battery, and finally the thermoelastic adhesive is applied. This means that in the second action, the LED is switched on, emitting light and consuming the battery's energy. Given that it was necessary to have several flywheels ready for use during the preparations...

According to the specifications of the work, the LED-battery system would have to be assembled in advance, but the LED would have to remain switched off until it was needed, meaning that a power switch was required to turn the illuminated steering wheel on and off. The solution was extremely simple: a piece of acetate film was placed between the cathode and the negative polarity side of the battery, interrupting the flow of electrical energy. Thus, the LED-battery system could be mounted on the steering wheel and turned on only when necessary.

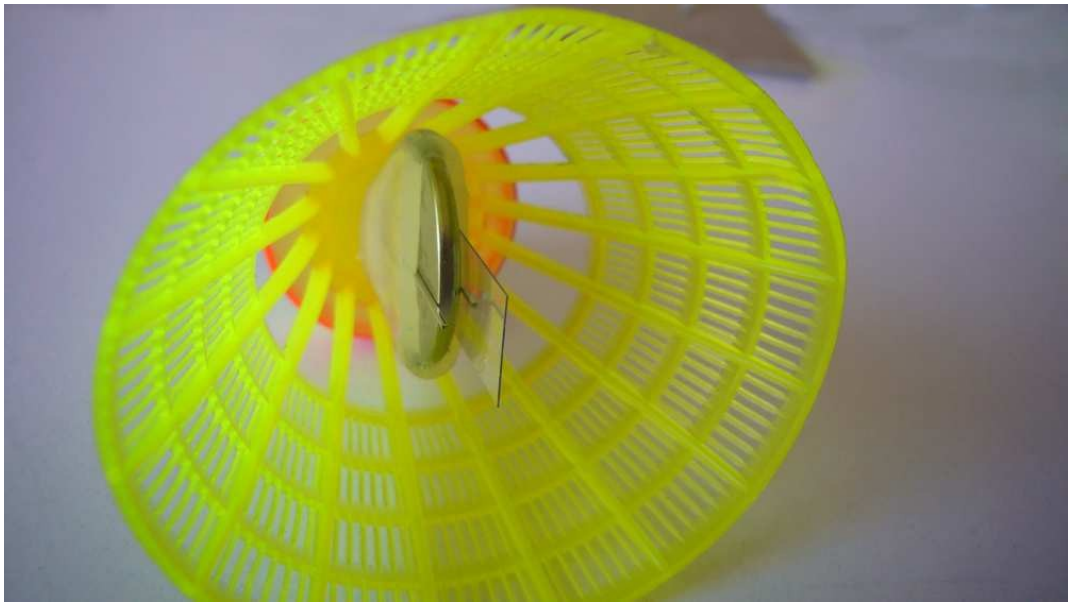

Figure 59. Illuminated steering wheel switched off. André Rangel 2011.

One may question the importance of developing and describing this system in the context of a doctoral thesis, but in fact, this system is central to the *SynDyn* work. The absence of this system would render the work unfeasible, as the luminous flywheel is a 'scratching' material in the light drawings that result from the *SynDyn* work. Affirming the equality of the media in the intermediate process, it should be noted that in the context of the present research, the LED-battery system as a medium, resulting from the fusion of media, was treated with the same dignity as any medium that integrates the *SynDyn* work. In this work, the rubber sleeve is a fundamental medium in the fusion process that results in the new medium — LED-battery. The rubber sleeve has a value

equivalent to the value of the modern computer, the algorithm it executes, or the programming language in which that algorithm is described and constructed. *SynDyn* depends equally on all media and their interaction in the intermedia dynamics from which it results.

HARDWARE INTEGRATION

The integration of radios and Arduino microcontrollers triggered a new series of questions in the reflective practical research developed in this PhD, namely, where these devices should be placed — on the racket or on the users' bodies — and how they should be mounted and protected. The answer to this dual problem essentially resulted from dialogue with the specific situation and the materials that were considered for use. Ultimately, it is a semantic design, as the material options discussed earlier in this text are semantic options.

The answer to the first question — where the devices should be placed — comes from experience, consideration, and testing of various hypotheses that were taken into account. Initially, it was considered to place the devices — radio and microcontroller — in the racket itself, but it was quickly understood that this hypothesis, in addition to altering the dynamics of the racket itself, would imply a large investment in miniaturisation, which is a more expensive process. The second hypothesis considered was to place the devices on the users' arms, but given that, as it is a racket sport, the physical activity performed in *SynDyn* involves intense use of [the arms], it was decided to leave them as free as possible. To ensure the physical integrity of the players

444 In addition, during the practice of racket sports, it is common for the arm holding the racket to come into contact with the player's chest and head in some movements, so the placement of a rigid volume (which integrates the radio and microcontroller) could injure or inhibit the players' movements.

After evaluating the various types of sensors and devices, it was decided to place them on the players' backs, secured to a hybrid harness and strap system. This system consists of a 12 cm wide elastic band, adjustable in length, with a Velcro fastener. This band rests on the player's back — at chest height, it passes under the armpits to the front of the body and finally around the back of the neck.



Figure 60. Simplicity of elastic band placement. André Rangel 2011.

The fact that there is an electroluminescent wire around the rim of the racket and a sensor in the racket's net meant that two pairs of cables were needed: two cables to power the electroluminescent wire and another two cables to connect the sensor to the microcontroller. To conceal the cable powering the electroluminescent wire, it was decided that instead of having a cable carrying electricity from the power supply from the player's back to the electroluminescent wire in the racket, it would be more aesthetically effective for the electroluminescent wire to run to a connection point closer to the power source. Thus, instead of only existing in the perimeter

445 The design of this system for attaching the devices to the body was inspired by the way an armpit holster works.

446 The power supply for the electroluminescent wire consists of batteries and a current inverter. The electroluminescent wire operates on alternating current, but the batteries supply direct current, hence the need for an inverter to convert direct current into alternating current.

The wire, which is one metre long, also runs along the participant's arm to their shoulder. This solution allowed the racket to be semantically affirmed as an extension of the body, unifying the participant's entire arm with the racket. In addition, what was initially a purely functional energy transport route was transformed into a line of light that enhances the scenic effect in *SynDyn*. Thus, in the resulting light designs in *SynDyn*, all blue trails correspond to the integrated movement of the arm and racket.

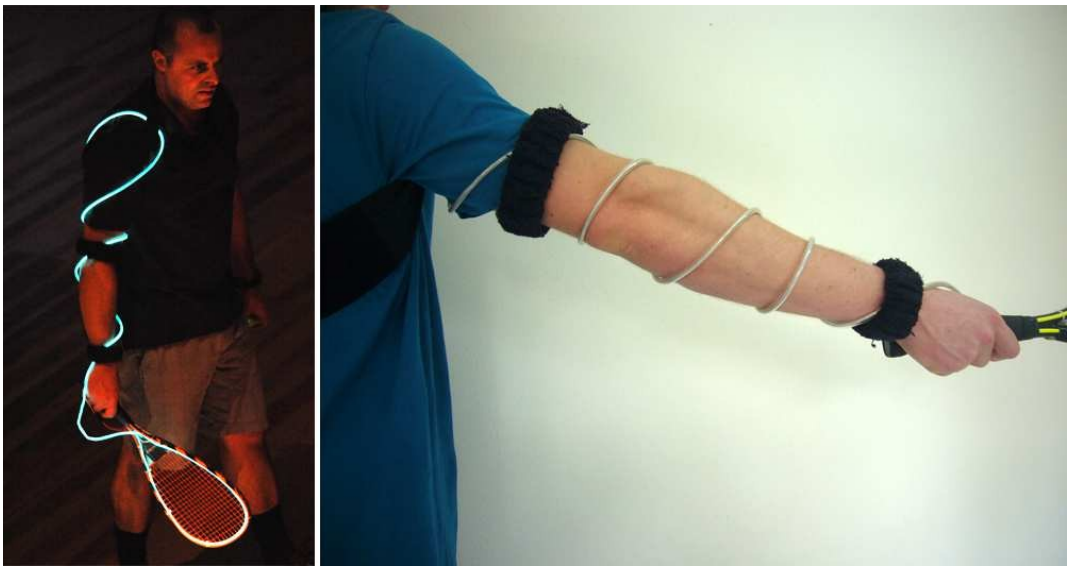

Figure 61. Luminous data transport cable. André Rangel 2011.

Given that there were two more cables that would have to follow the same route, from the racket to the player's back, it was decided, for the sake of simplicity in putting on and taking off this equipment, that the sensor cables should be attached to the electroluminescent wire. This connection was achieved by inserting the electroluminescent wire and the sensor data cables for the microcontroller into a thin, highly flexible and transparent rubber tube, normally used in medical nursing applications. Semantically, the set of cables came to be understood as a single wavy line of uniform quality.

The answer to the second question posed earlier in this section — how the devices should be assembled and protected — is designed with two factors in mind: waterproofing and shock protection. Given that intense physical activity invariably causes sweating, it was necessary to accommodate the electronic devices inside a waterproof box. At the same time, given that this box would be used close to the participants' bodies, who could suffer a fall during physical activity, the box would have to be hard enough to protect the electronic components inside and flexible enough not to break and injure users.



Figure 62. First prototype of a customised box for protecting the microcontroller, radio and power supply. André Rangel 2011.



Figure 63. Second version of the box made of more flexible material. André Rangel 2011.

In the first *SynDyn* prototype, the physical connections between the sensor and the microcontroller, as well as between the electroluminescent wire and the power supply, were secured by sets of four small [connectors] measuring 2.45 mm by 11 mm. However, this type of connection did not provide the robustness and simplicity of [connection448] that was desired for a work that involves sudden and intense body movements. The selection of the *SynDyn* work to be included in the International Festival of Electronic Language — FILE in São Paulo triggered the redesign of *the hardware* in *SynDyn*, mainly to make it more robust and easier to assemble and disassemble. In addition to the redesign of the box that houses the microcontroller, the radio and the power supply for the electroluminescent wire, the main transformation took place at the connection level.

447 https://www.sparkfun.com/products/116

448 Connecting these connectors required some care to avoid reversing the polarity.

which is now provided by a single RJ11 [449] connector, which is the traditional connector for telephone cables. In this context, it is worth mentioning the fortunate coincidence that telephone cables and RJ11 connectors have precisely four channels, which is exactly the number of channels needed to carry electrical current to the electroluminescent wire (two channels) and to transmit data from the sensor to the microcontroller (another two channels). In addition, the RJ11 connector has a lock, which ensures that the connector is not disconnected when pulled. This coincidence, combined with the ease of obtaining RJ11 connectors from obsolete electronic scrap, led to this connector being integrated into the *SynDyn* interface. Affirming the serendipity of the construction process in an intermediate work, the choice of the RJ11 connector led to the discovery of connectors mounted on helical telephone cables during the search for reusable connectors. In addition to the functionality of the helical telephone cable, which allows it to be stretched to three times its length, and its flexibility, the semantic value of this type of cable is undeniable. This cable is associated with a generation of devices that are fundamental to the history of communications: corded telephones.



Figure 64. End of the luminous data cable with RJ11 connector. André Rangel 2011.

449 http://en.wikipedia.org/wiki/Telephone_plug

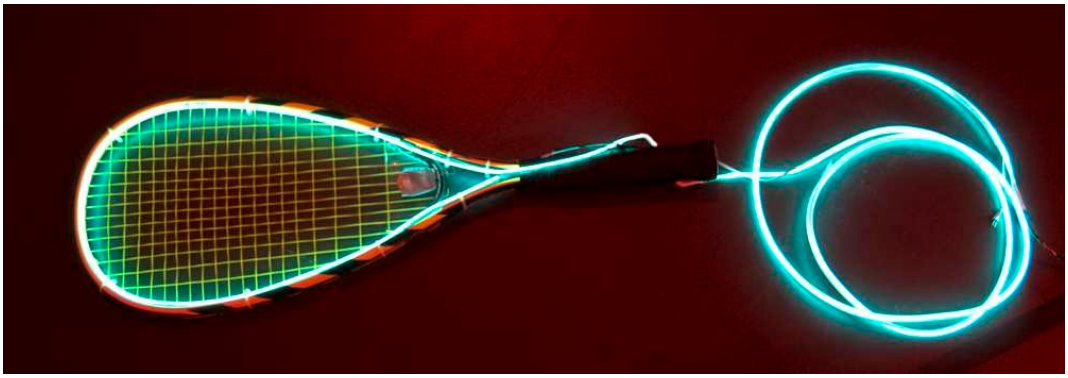

Figure 65. First prototype of the luminous racket. André Rangel 2011.

As mentioned earlier in relation to the ColMus project, the reuse and subversion of media was also part of the reflective practical research that resulted in *SynDyn*. From the flexible rubber tube, designed for medical purposes, for transporting fluids, used in *SynDyn* as a protective and insulating medium for cables or as a means of attaching the LED to the battery, to the rackets themselves, designed for sports performance, used in this work as drawing tools, to the RJ11 plug, designed for landline telephones, several means were subverted in *SynDyn*, giving them a new function and utility.

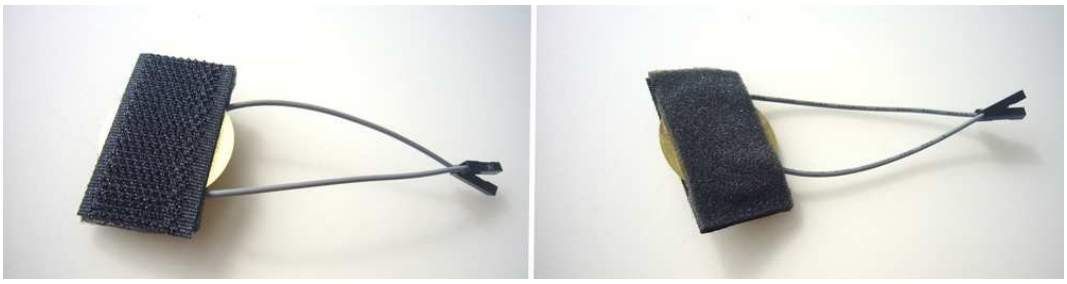

Figure 66. Electro-ceramic piezo with Velcro on one side for easy replacement and spongy material on the other to cushion impacts. André Rangel 2011.

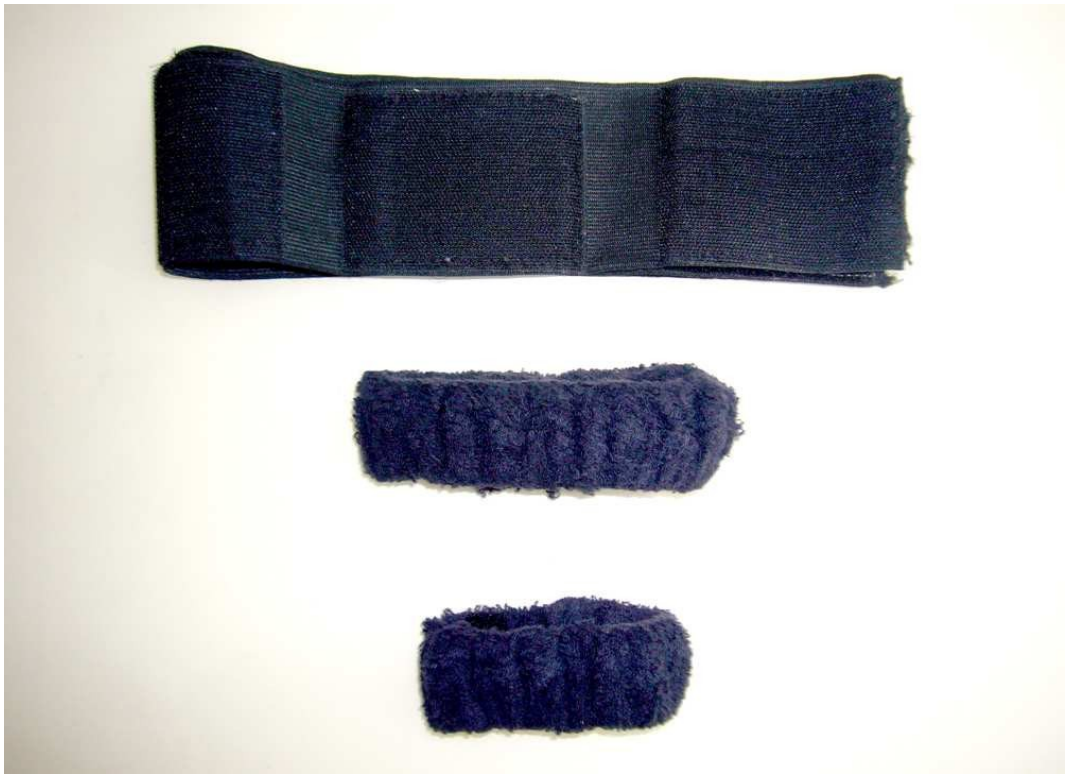

Figure 67. Elastic band, armband and cuff. André Rangel 2011.

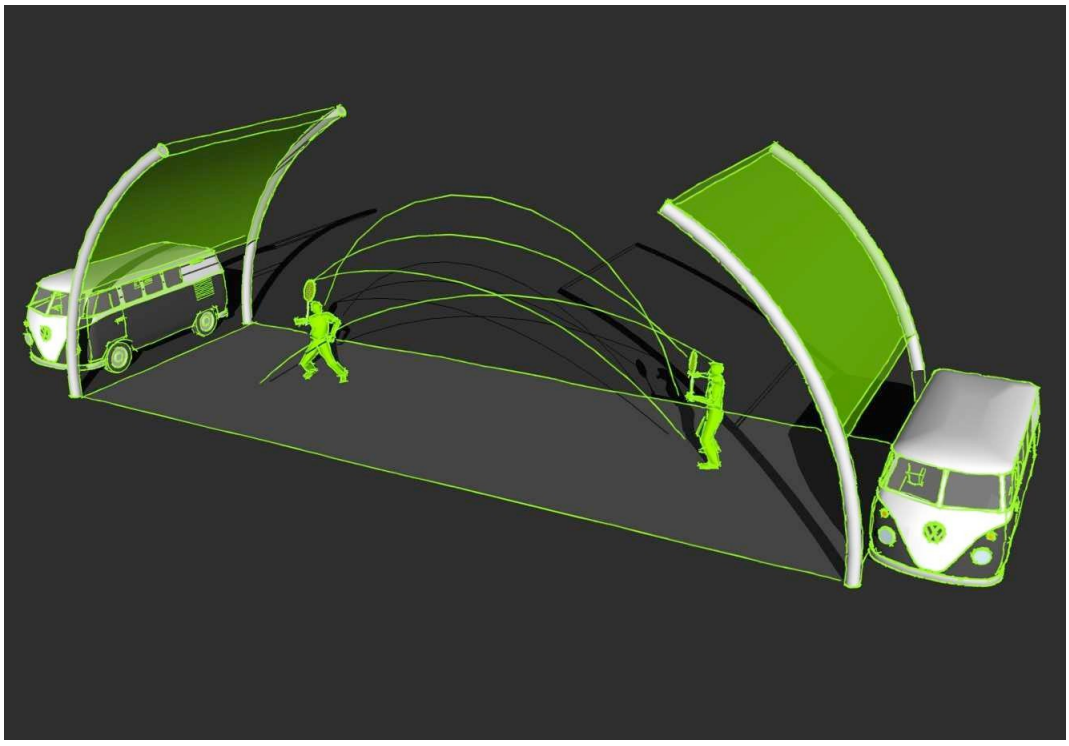

Figure 68. Initial sketch for presentation to partners. Drawing by Anne-Kathrin Siegel 2011.

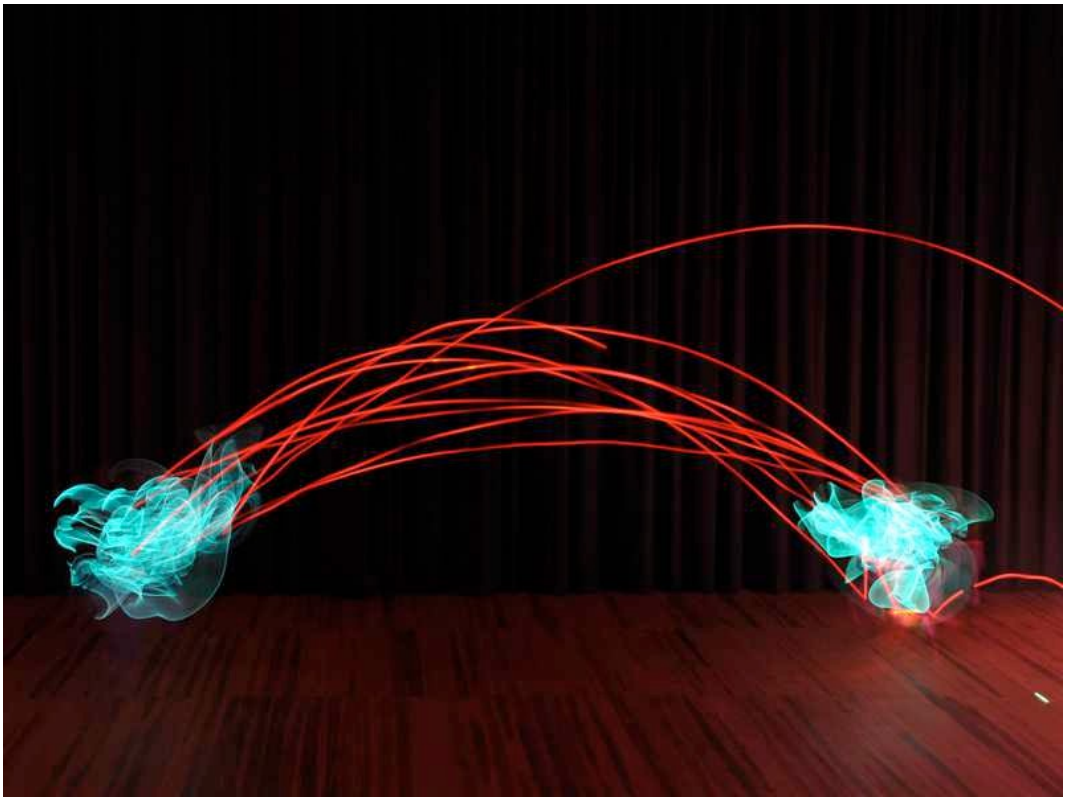

Figure 69. Light design at the Portuguese Catholic University. Photograph by Luis Maruta 2011.

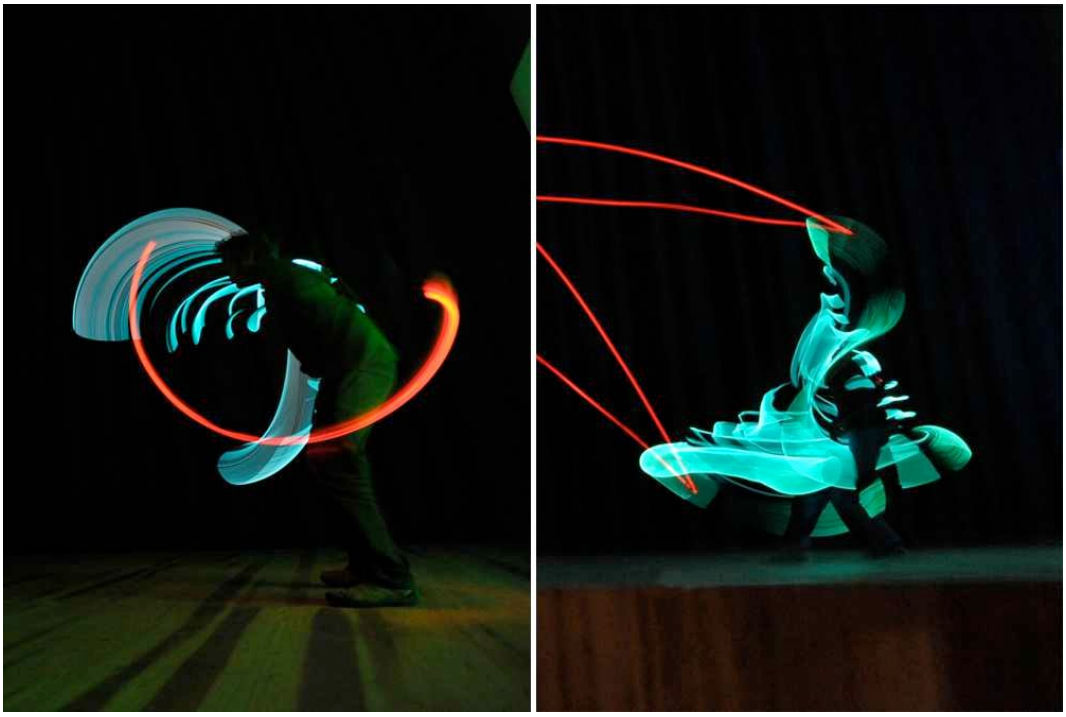

Figure 70. Light design at the Portuguese Catholic University. Photograph by Luis Maruta 2011.

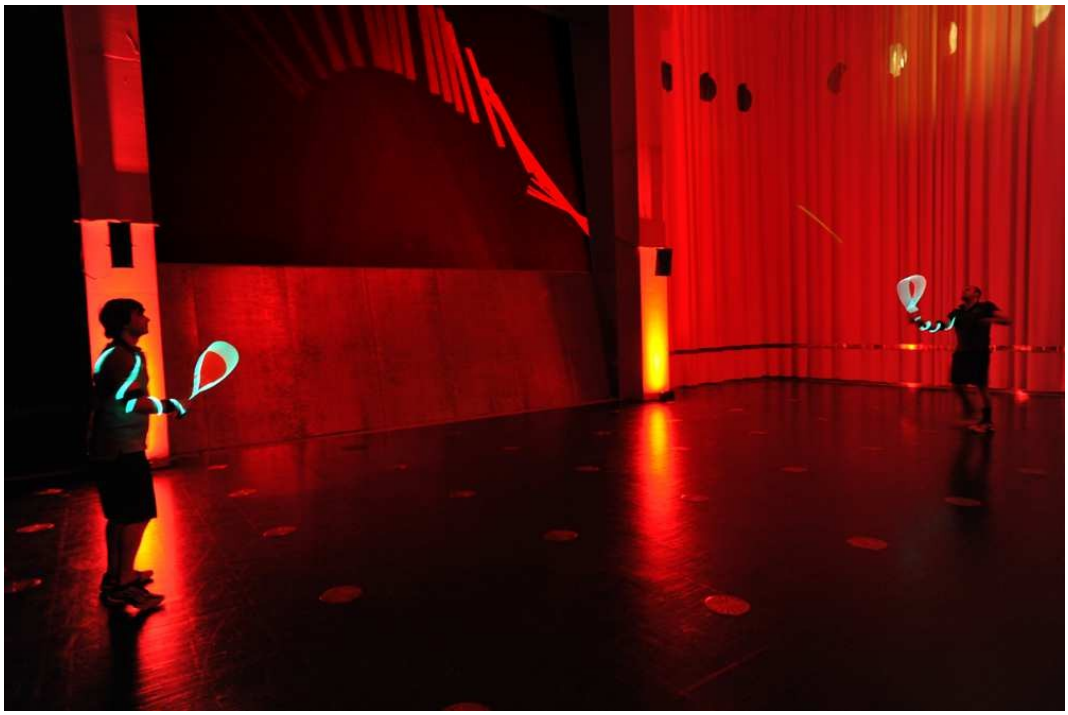

Figure 71. SynDyn at Casa da Música. Photograph by Luis Maruta 2011.

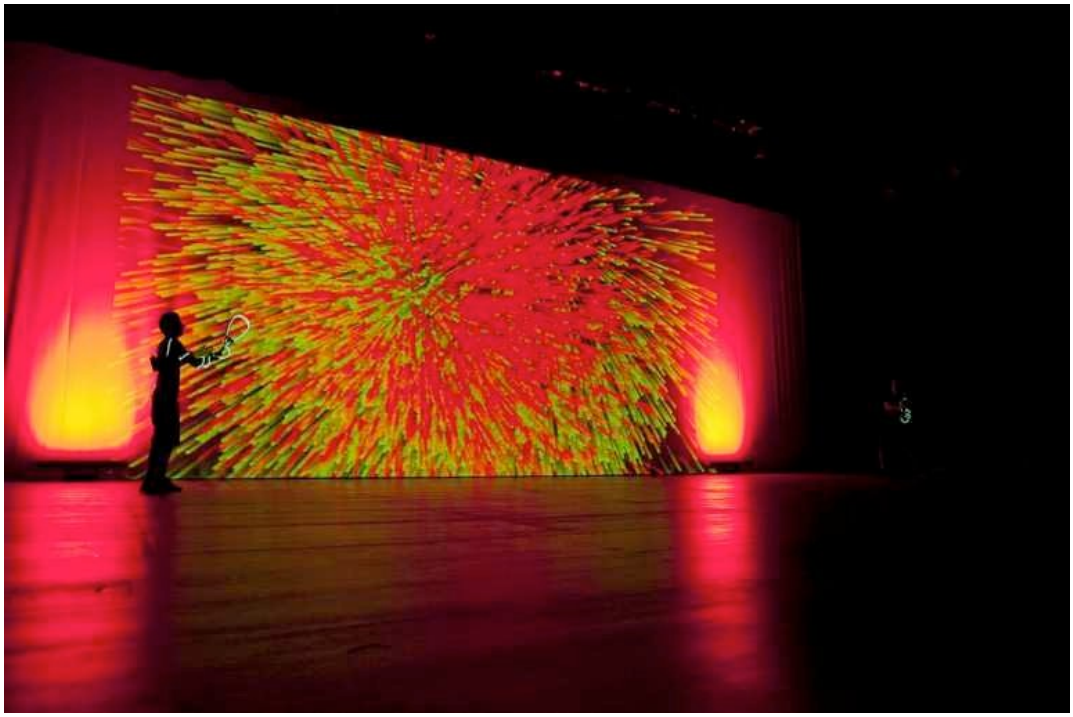

Figure 72. SynDyn at the FILE Festival. File.org.br 2011.

PARTNERS

The SynDyn project, in addition to being the result of a process of reflective practical research, required a huge investment to ensure all the technical and human resources necessary for its implementation and documentation. Given that this was a project without a budget and without any financial support from any public or private institution, efforts were made to obtain all the resources that were not available at the Portuguese Catholic University, which hosted this research project. In the logistics strategy designed and developed, manufacturers, sellers and/or owners of materials or resources essential to the realisation of this work were asked to lend these materials in exchange for the status of partners in the production of the work.

The spectrum of partners is broad and diverse, ranging from the Asian manufacturer of electroluminescent wire — *Lytec*[450] — based in Hong Kong; to the company selling lighting equipment for cinema and television — *Light-Set*[451] , which kindly provided the lighting devices; Casa da Música do Porto,[452] which kindly provided the aforementioned Lanbox LCX interface, as well as a room for assembling the prototype; *InMotion*[453], representative of the electronic products and sensors used in the work; and *Speedminton,*[454] which kindly offered two pairs of rackets. As it was physically impossible to test the concept and simultaneously document it without people, it was necessary to gather and organise human resources, such as inviting people to participate in the work and inviting assistants to operate the cameras on the days when the audiovisual documentation of the work was recorded.

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450 http://www.lytec-asia.com/

451 http://www.lightset.pt/

452 http://www.casadamusica.com/

453 http://inmotion.pt

454 http://www.speedminton.com/

DISSEMINATION OF WORKS

In order to reiterate what was written earlier at the end of the section 'Reproducibility and memetics', more specifically that the knowledge generated in this research cannot be expressed linguistically, it is stated that the intermedia works resulting from the reflective practical research developed in this PhD, as well as the audiovisual documentation on them, are valid in themselves as a means of transmitting intermedia knowledge.

Regarding the ineffability of the works, Grady (2011) reports that SynDyn 'is one of those projects that is virtually impossible to describe in words'[455]. The public recognition given to this work can be seen in the number of publications on websites and blogs. Baron (2011), senior creative at Saatchi and Saatchi in London and curator of the blog *20 minutes into the future*[456], dedicated, among other topics, to 'digital discoveries and technical odysseys that give us goosebumps', publishes and recommends viewing the audiovisual documentation of this work.

Poyau (2011) published an article dedicated to SynDyn on the blog the creators project[457], in which he states that 'digital and new media artists are recognised for their ability to appropriate diverse creative fields and disciplines. Most of the time, this synthesis remains hesitant, limited and within the strict boundaries of the classic encounters between art, science and technology.' Poyau also considers that SynDyn firmly breaks this monotonous cycle and explores new horizons. Underlying this criticism, one can argue the undisciplined nature of the work SynDyn. In the same text, this work is considered 'an ambitious creative experiment that aims to merge aesthetics, physical activity and

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455 Author's translation from the original: *'This is one of those projects that is almost impossible to put into words*'. (Grady, 2013)

456 http://20minutesintothefuture.co.uk/?p=427

457 http://thecreatorsproject.vice.com/blog/can-sports-and-art-finally-come-together-in-this-interactive-installation

leisure.'[458] Poyau concludes his text by emphasising the hybrid nature of SynDyn and, in a way, its ineffability and unclassifiability:

> Is it a sport? Is it a game? Is it art? Frankly, we are not sure, nor are we certain that it still matters. Traditional barriers of distinction are continually being subverted by artists to the point of obsolescence, and this hybrid project is just one example of an interactive environment that positions artistic creation as an integral and inevitable component of the experience. And we are apologists of that.[459] (Poyau 2011)

A few months later, the same author mentions that SynDyn may even have inspired IRCAM in developing a similar performance applied to basketball. Sgobbi (2011), in the DAAF blog, considers SynDyn to be 'a project born from the extraordinary idea of combining sport and art in a unique creative and sensory experience.' Modugno (2011) publishes documentation on the work on his blog with the following description:

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458 Translation by the author from the original: '[...]*is an ambitious creative experience that aims at merging aesthetics, physical activity and leisure.*' (Poyau, 2013)

459 Translation by the author from the original: *'Is it sport? Is it a game? Is it art? Frankly, we're not sure and we're also not sure it really matters anymore. The traditional barriers of distinction are continuously being subverted by artists to the point of obsolescence and this hybrid project is just one example of an interactive environment that positions artistic creation as an integral and unavoidable component of the experience. And we're all for that.*' (Poyau, 2011)

460 http://www.ircam.fr/

461 *'Some time ago, we told you about SYNDYN, a project combining digital art, sport and leisure. (...) A work/game that seems to have inspired IRCAM, a contemporary music research centre, institutional and highly theoretical, which has created a similar performance.*' (Poyau, 2011b)

462 http://www.daafportal.com/index.php?option=com_k2&view=item&id=356:3kta-+-andrè-rangel-e-anne-kathrin-siegel&lang=en

463 Translation by the author from the original: 'A project born out of the extravagant idea of uniting sport and arts in a single creative and sensory experience.' (Sgobbi, 2011)

Alternatively, there are those who try to change the rules, to insert something innovative into a game as old as the world itself, something capable of leaving us speechless, of opening our minds, of making us feel envious, because we would have liked to have done it ourselves, but did not for reasons beyond our control. (Modugno, 2011)[464]

The documentation on the work was disseminated by different blogs and web pages with themes ranging from architecture to art, design, video games, technology, among others. This dissemination of documentation on the work has allowed the video report[465] on the SynDyn work to be viewed more than 12,800 times to date. The work's participation in the FILE Festival, which attracted more than 40,000 visitors and distributed 22,000 magazines and 1,000 catalogues, certainly allowed the idea behind the work, or information about it, to be disseminated to an unknown number of people. Another reference to the work, of great importance in the international context, is the inclusion of a hyperlink to the documentation on the work in the list of references on art, science and technology in Leonardo magazine, specifically in the section on synesthesia[466].

With regard to SoLu, in addition to the thousands of views that the video report on this work received and its presence at four international conferences, as mentioned in the 'SoLu' section, highlights include a review[467] by Ciociola (2011) in the digital version of Neural magazine, a news item in issue 38 of the print edition[468] of the same magazine, as well as the reference made by Martins and Barbosa (2013) to the SoLu project as an example of projects designed

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464 Translation by the author from the original: *'There are those who try to change the rules, to introduce something innovative into a game as old as the world itself, something that leaves us speechless and opens our minds, making us feel a twinge of envy because we would have liked to have done it ourselves but, for reasons beyond our control, we did not.*' (Modugno, 2011)

465 Video report available at: http://vimeo.com/20859799

466 http://www.leonardo.info/isast/spec.projects/synesthesiabib.html

467 http://neural.it/2011/03/solu-correspondence-between-audio-and-visual-spectrum/

468 http://neural.it/issues/neural-38-p2p-f2f/

involved in the School of Arts at the Portuguese Catholic University, in the area of new interfaces for musical expression.

On the night it was presented, GreenRay was experienced by around 1,400 people. In addition, the audiovisual documentation on the work was also seen by several thousand people. This documentation was selected by curators of important publications on lighting and architecture, notably the magazine enlighter[469], where GreenRay is presented alongside works by authors such as Zaha Hadid and United Visual Artists, and the blog[470] of the Media Architecture Institute[471].

The work also attracted the interest of Vivian van Gaal[472], artistic director of the STRP[473] festival, who officially invited the work to be installed as the gateway to the 2010 edition of the festival. Due to logistical and financial constraints, this invitation could not be accepted. As described, part of this work consists of a sculptural/architectural approach constructed with laser beams and mirrors. Although this may be mere coincidence, and although it is not the first work of art to use lasers or mirrors, it was noted that, following the publication of documentation on GreenRay in October 2009, other notable works appeared on the international scene that use precisely the same approach: sculptural objects constructed with laser beams and mirrors. Notable among these works are the projects by the *GNI*[474] collective from 2010 onwards and the *Speed of Light* project by the *UVA*[475] collective in 2010. However, the inclusion of the audience in the modelling of the work in GreenRay gives it a distinctive quality. This quality is common

469 http://www.enlightermagazine.com/projects/greenray-lux-fragil

470 http://www.mediaarchitecture.org/green-ray-lisabon/

471 http://www.mediaarchitecture.org/

472 http://www.linkedin.com/pub/vivian-van-gaal/4/910/325

473 http://strp.nl/nl/

474 http://www.gni-projects.com/

475 http://www.uva.co.uk/work/speed-of-light

to the works resulting from the research carried out in this PhD, which go from being objects to provocative subjects, acting on the audience, leading them to perform actions that they would never perform without the works.

CONCLUSION

This research was established to determine the type of dynamics underlying intermedia practice and thinking at the beginning of the 21st century. It also sought to contribute to clarifying the controversy surrounding the extemporaneity or topicality of the subject. In this sense, this research brings together arguments that can validate such practices and thinking as valid research activities in the academic and artistic context. The importance of this research lies in its potential to stimulate free thinking and artistic and design activities, within or outside the academic context, using any means, without any disciplinary or gender prejudice or constraints. In other words, it reaffirms and promotes a condition of equality of means in the process of creating hybrid works that should not be constrained by conventional and recognised genres such as painting, sculpture, sound art, visual art, digital art, video art, music, architecture, the various genres of design, interactive art, animation, among others.

The synchronic approach — of reflective practical research, which results in works that simultaneously address the questions and answers of the research itself — and the diachronic approach — of reviewing literature where the characteristics and antecedents of intermediation at the beginning of the 21st century were identified — allowed us to conclude that the dynamics of intermediation at the beginning of the 21st century are essentially undisciplined. These dynamics, in addition to acting within the limits of the research itself, are also influenced by the context in which they occur.

verifiable in the works resulting from practical research — led to the conclusion that the dynamics of intermedia at the beginning of the 21st century are essentially undisciplined in nature. These dynamics, in addition to acting on the boundaries and in the interstitial space-time of media and disciplines, can also integrate interdisciplinary, transdisciplinary and multidisciplinary actions. However, they are predominantly undisciplined dynamics because, according to the requirements of the actions themselves, they act indiscriminately 'in' within the disciplines, using their deepest foundations and premises, but also 'in' shamelessly denying those same premises and foundations. This challenged and updated Higgins' proposal, for whom intermedia operated essentially between media, between disciplines.

The undisciplined nature of intermedia can be associated with another conclusion of this research: intermedia is timeless, and therefore always current. However, intermedia has not always been recognised and validated in the artistic and academic world, which is formatted into a system of knowledge hierarchy and disciplinary division that evolved from the age-old split between rationalism and idealism.

The mixing and merging of media, resulting in new media, will be a constant in human history. However, the name for this type of transformative action was only established in the arts in the mid-1960s. The very subversion and transformation of the functionality of media, validated in the artistic domain with the introduction of Duchamp's Ready-made or the Futurist and Dada movements, is also a constant in the evolution of humanity, since, to this day, one of the characteristics of human beings is their desire and need to create media and transform them. From this timeless point of view, the age of media no longer makes sense; all were new and all will be old, all were high-tech and all will be low-tech. Intermedia is therefore as old and modern as human beings, except that it is not yet

sufficiently integrated and validated in artistic and academic circles.

From reflective practical research and the resulting works, combined with a review of literature, specifically literature from areas such as systems theory, biology, philosophy and art, it can be concluded that both the dynamics of the process and the resulting intermedia work itself are open autopoietic dynamics. This conclusion is directly related to and supports others, which were concluded to be undeniable characteristics of intermedia: its openness to serendipity and its indeterminism. The permeability of open autopoietic dynamics in intermedia systematisation allows exchanges with the outside of the system, which contributes to the modelling of the creation system itself, as well as the resulting works.

Due to its indeterminate, laboratory-like, processual nature, its capacity for synthesis and, above all, its transformative role, it is possible to establish an affinity between intermedia artistic experimentation and scientific experimentation, specifically with experimental chemistry. The ability of intermedia and chemistry to generate new material or conceptual means, and the mixture of thought with physical action, are other arguments that support this affinity. It can also be concluded that Coleridge's original concept of the intermedium as a catalyst remains relevant today, being suitable for sustaining the same affinity, as well as for approaching a definition and characterisation of intermedia.

From the analysis of human experience in the process of intermedia research and in the resulting works, as autopoietic systems, it can be concluded that human beings (artists, designers, producers, and audiences) are entities that interact as part of the system itself and not with it. From this, it can also be concluded that human beings are means in the intermedia phenomenon

phenomenon and that their experience in this phenomenon occurs mainly in an enactive manner. Thus, human experience in an intermedia system and the knowledge generated and acquired therein are mostly tacit, provided by enactment, and therefore ineffable. The intermedia works resulting from the reflective practical research developed in this PhD are not objects, but rather events of enactive dynamics, and can therefore be concluded to be essentially presentative works. In these events, the actions of contemplating and making the work are unified, eliminating the subject/object relationship, in what is called endo-aesthetics. Thus, tacit knowledge, stimulated by the interactive aesthetics of intermedia works, depends on a process of reciprocal improvement between perception and transformative action.

Although the academic context may be considered constraining, coercive and rigid for the development of innovative ideas, the work and reflective practical research developed in the synchronous approach of this PhD were viewed without constraints, as a 'game', allowing the researcher and, conferring optimism, enjoyment, positivism and freedom on the research work. The emerging and intrinsic motivation of a passionate reflective practice, in addition to making the research process a pleasant and spontaneous activity, conditioned the very result of that process: the resulting works. In this research process, the emerging and intrinsic motivation forced the expansion of the researcher's structure of interests, as well as the expansion of his skills in relation to those interests. The researcher continuously adjusted his actions based on feedback from the research process itself and on the emerging motivation, leading to the research process evolving in a fluid and homogeneous manner.

The practical-theoretical knowledge used and resulting from the process of reflective practical research in intermedia is ineffable. This knowledge results from experimental interaction with the media, from dialogue with them in

design of the system that allows for the existence of the intermediate work. The researcher's actions in this process are conscious, simultaneously materialising questions and answers. They are reflective, thoughtful and theoretical acts which, by dealing with the semantic value of the materials, resources and techniques themselves transformed into means, contribute to the construction of the work's meaning. This and its materiality are therefore language, unutterable but communicable, which leads to the conclusion that textual and literary research processes are simpler than practical intermedia research processes. Thus, the intermedia work contains an informative dimension that integrates the questions and answers formulated in and by the work itself. However, written verbal language is inadequate to translate this type of questions and answers, as well as the theoretical thinking inherent in reflective practice.

In the academic context, the reproducibility and dissemination of research results are often associated with the validation of the research itself. However, it is considered that in reflective practice research, originality and distinction should be considered criteria of relevance rather than the reproducibility of its results. In turn, it is concluded that the criteria 'contribution to knowledge' and 'dissemination of research results' are appropriate for the validation of reflective practice research in the academic context. Contributing to knowledge means contributing to cultural evolution and the evolution of ideas. The works resulting from reflective practical research are materialisations of ideas, which result from decisions made between possible alternatives. These works can function as receptacles, which are valid as means of transmitting knowledge, at the service of the selectemes of those who engage with them. It can therefore be concluded that the work of art and intermedia design is a better means of communicating its contribution to knowledge than its verbal description.

The main limitation of this study is that this thesis does not include a review or references to other works by other authors, also developed in the first thirteen years of the 21st century.
. The relationship between the review of these works and the literature review could have made it possible to identify other characteristics of intermedia not discussed in this thesis. Although this review did take place, as during this research works by other authors were consulted, mainly to verify the originality and relevance of the works developed in this doctoral thesis, it was decided not to include this review in this text for two reasons. Firstly, because in order to include references to other works in this thesis, it would be necessary to construct a model of criteria for their selection. Instead, priority was given to total dedication to a process of reflective practical research, which allowed for the knowledge and intrinsic experience inherent in this process. Furthermore, as the aim is to establish a model of reflective practical research, it was considered that the best way to understand it would be to experience it. These choices may have limited the research, but, on the other hand, they allowed for a broad understanding of the inner workings of the reflective practical research process, rather than an external view of other authors' research processes and their results.

This research discussed several characteristics identified in the intermediary dynamics, among which the following stand out: undisciplined, fluid, indeterminate, hybrid, experimental, laboratory-like, threshold, transformative, continuous, enactive, presentative, autopoietic, subversive, free, tacit, and memetic, among others. In order to complement this research, future research is proposed that will develop in the direction of deepening the study of the specificity of one or more of the characteristics already identified in this thesis. In this sense, we suggest the observation, critique, and analysis of a set of intermedia works by different authors that show affinities because they share the same characteristic or set of characteristics. This research strategy could facilitate

an understanding of the approaches developed by different authors to give the works the characteristic(s) under study.

Another possibility for future research would be to develop more comprehensive research that would allow us to identify other characteristics of intermedia dynamics not identified in this thesis. In this research strategy, it would make sense to conduct a survey that integrates a set of different works and, based on their analysis, identify other characteristics not described in this thesis. This research hypothesis could also incorporate a global view of attempts to create intermedia systems, discussing some of the most relevant historical examples in this field of creation, both before and after the introduction of the term intermedia, in an attempt to identify the themes, resources, objectives and constraints that may have structured the design of these systems.

The design of an analytical model for studying intermediary systems that would allow us to distinguish and analyse the qualities and interactions between static structural elements and dynamic functional elements observable in intermediary systems would be another hypothesis for future research. In this research hypothesis, the model could be developed based on, or derived from, other models used in various fields of scientific and artistic research, such as sociological, historical, technical, technological, and psychoanalytical analysis models, among others. The new model should be tested according to criteria of robustness and adequacy, which, if confirmed and demonstrated, would validate this new model as a basis for the structural design of new intermedia systems.

Outside the artistic context, there is also the hypothesis that research in intermedia could be approached as a topic in the sciences of education, transforming the undisciplined nature of intermedia research itself into a research problem in the field of education. This research hypothesis

would draw on the advanced and specialised knowledge of contemporary educational sciences, with the main objective of constructing models or curricular programmes that legitimise the dignified integration of reflective intermedia practice in academia in Portugal.

The proposals just outlined do not exhaust the possibilities for research in intermedia, nor does this thesis exhaust the research possibilities suggested by initial expectations. Therefore, intermedia deserves ongoing and continuous attention from both an artistic and scientific point of view. That said, considering all the research possibilities mentioned and those not yet mentioned, it can be concluded that, in the field of intermedia, the greatest contribution to knowledge and cultural evolution is the continuation of creating new intermedia works through free, practical and reflective research.

APPENDICES

INTERVIEWS

During this doctoral project, 100 interviews were conducted with the dual aim of updating the definition of the term 'intermedia' and assessing the interviewees' actual understanding of the issues surrounding this definition. In this interview project, the 100 individuals interviewed have different professional and/or academic backgrounds, but are all connected to the field of art or artistic production. The identities of the interviewees will be compiled and presented, as well as transcripts of excerpts from those interviews that proved to be most relevant in answering the three questions asked: What does media mean? What does intermedia mean?; and What is the relationship between theory and practice? In order to reinforce the contribution of this research to knowledge, it was decided to make the interviews available in full at the following url: http://hyperinstrument.com/interviews/

Alan Dix



Expert in the field of human-computer interaction. Author of a university-level textbook entitled Human-Computer Interaction. Currently a professor at Lancaster University.
Location Aveiro, Portugal
Date 24 September 2010

Alessandro Ludovico



Media critic and chief editor of Neural magazine (honourable mention Prix Ars Electronica 2004). Co-editor, 'Mag.Net Reader'. Teaches 'Computer Arts' and 'Interface Aesthetics' at Carrara Art Academy, Italy.
Location: São Paulo, Brazil
Date: 20 July 2011

Alexander Römer



Collaborative architect and carpenter. Member of the Collectif EXYZT, worked with a wide range of creative collectives, designers and architects.
Location Porto, Portugal
Date 2 April 2011

Andreas Broeckman



Artistic Director of transmediale – international media art festival Berlin. Studied art history, sociology and media studies. Worked at V2_Organisation Rotterdam, Institute for the Unstable Media.
Location Porto, Portugal
Date 18 May 2012

Antonio Camurri



Associate Professor, University of Genova, teaches software engineering and multimedia systems. Among many other projects, he is Founder and Scientific Director of the InfoMus Laboratory.
Location Porto, Portugal
Date 26 March 2011

Benoit Maubrey



Performance artist, 'electroacoustic sculptor', punk musician, and choreographer. **Location** Porto, Portugal
Date 15 October 2010

Blaine Reininger



Co-founder of Tuxedomoon – experimental post-punk/new wave, avant-garde, electronic-oriented collective whose music ranged from new wave pop to jazz fusion to more experimental synthesiser soundscapes.
Location Porto, Portugal **Date** 15 October 2010

Blake Turner



New Media Artist, Floating Lab Collectivehttp://www.floatinglabcollective.org/ **Location** Indianapolis, USA
Date 23 April 2010

Brandon Labelle



Artist and writer working with sound and the specifics of location. His work explores the space between sound and sociality, using performance and on-site constructions as creative supplements to existing conditions.
Location London, UK
Date 6 July 2010

Bruce Pennycook



Professor at UT Austin – Specialised in new media and audio technologies including music visualisation, interactive music performance and network-based audio.
Location Covilhã, Portugal
Date 8 April 2010

Bruno Dias



Researcher at the Philosophy Centre of Lisbon University and member of Númena – Investigation Centre on Human and Social Sciences. Coordinator of the book 'Política dos Muitos'.
Location Porto, Portugal
Date 17 May 2012

Christof Migone



Artist, curator and writer. His work and research delves into language, voice, bodies, performance, intimacy, complicity, endurance. Lecturer in the Department of Visual Studies at the University of Toronto Mississauga and the Director of the Blackwood Gallery.
Location Porto, Portugal **Date** 13 October 2011

Christopher Burns



Chamber and electroacoustic music composer and concert producer. Teaches composition and technology at the University of Wisconsin-Milwaukee. Previously, Technical Director of the Centre for Computer Research in Music and Acoustics at Stanford University.
Location Indianapolis, USA
Date 24 April 2010

Christoph Haag



Designer, typographer and publisher. Studied art history and philosophy in Augsburg. Graduated in Audiovisual Media at the Academy of Media Arts Cologne.
Location São Paulo, Brazil
Date 20 July 2011

Cildo Meireles



Conceptual artist, installation artist and sculptor. One of the leading figures in the development of Conceptual art. His works mix the sensorial with the cerebral and vary in scale from the miniscule to the vast.
Location Porto, Portugal
Date 28 October 2010

Clarence Barlow



Composer, one of the founders of GIMIK: Initiative Musik und Informatik Köln, was director of music at the International Computer Music Conference in Cologne, was director of the Institute of Sonology, at the Royal Conservatory of The Hague.
Location Karlsruhe, Germany
Date 8 July 2012

Claudia Giannetti



Specialist in media art, theoretician and writer, curator of exhibitions and cultural events. PhD in Art History from the University of Barcelona in the field of Digital Aesthetics.
Location: Porto, Portugal
Date: 24 November 2010

Cretien Van Campen



Author of the book Hidden Sense and scientific researcher. Studies Gestalt theories in perception psychology, aesthetics and art history.
Location Almeria, Spain
Date 17 February 2012

Daan Roosegaarde



Artist and architect. Creative director of studio Roosegarde. Explores the dynamic relationship between architecture, people and e-culture.
Location Waddinxveen, Netherlands
Date 13 May 2010

Daniel Schorno



Composer, STEIM's Artistic Director until 2005. Currently STEIM's composer-in-research and creative project advisor.
Location Amsterdam, Netherlands **Date** 14 May 2010

Dave Phelps



Multimedia Technologist and Audio Engineer at IUPUI – Indiana University-Purdue University Indianapolis.
Location Indianapolis, USA **Date** 25 April 2010

David Kousemaker



Interaction Designer. Master of Arts in Interactive Multimedia. Founding member of Blendid (www.blendid.nl) and enjoys playing with technology as much as the next geek.
Location: Hilversum, Netherlands
Date: 11 May 2010

David Mc Donald



PhD Student at College-Conservatory of Music (CCM) – University of Cincinnati, composer, performer, saxophone player, computer programmer.
Location Indianapolis, USA **Date** 23 April 2010

David Rokeby



Interactive sound and video installation artist based in Toronto, Canada.
Location Porto, Portugal
Date 30 October 2010

Derek Black



Scientist, musician and concert producer. Researcher in computational fluid dynamics at Indiana University-Purdue University Indianapolis.
Location Indianapolis, USA
Date 24 April 2010

Diemo Schwarz



Computer Scientist. Researcher and developer at Ircam in real-time applications of computers to music, sound analysis/synthesis, and interactive corpus-based concatenative synthesis. Composer of electronic music, and musician on drums and laptop.
Location Amsterdam, Netherlands
Date 13 May 2010

Dirk Smeets



Chief Scientific Officer and Senior Researcher at icoMetrix, a specialised company in advanced image processing for quantitative analysis of biomedical images.
Location Lisbon, Portugal
Date 5 October 2012

Edgar Endres



Audiovisual Artist. Assistant Professor of New Media at George Mason University. Exhibitions at MoMA, The New England Film and Video Festival, Boston Fine Arts Museum, The New York Video Festival, and the Walter Reade Theatre, Film Society of Lincoln Centre.
Location Indianapolis, USA
Date 23 April 2010

Edward Dambik



Analyst and Programmer at the Advanced Visualisation Lab at Indiana University. Collaborator of Margaret Dolinsky.
Location Indianapolis, USA
Date 25 April 2010

Ella Rosewood



Dancer, performer, choreographer and educator. Interned with the Merce Cunningham Dance Company, New York Yoga, and Madison Ballet and currently interns at Ballet University in Verona. **Location** Indianapolis, USA
Date 25 April 2010

Erik Nyström



Acousmatic, electroacoustic, music composer. PhD researcher on structures and processes in spatial texture. Teaches contemporary music history and aesthetics, electroacoustic composition, and audio, at SAE in London.
Location Ljubljana, Slovenia
Date 14 September 2012

Felix Kubin



Psychotronitian, Dadaist, musician, producer, founder and owner of Gagarin Records. Played with Die Egozentrischen 2 and Klangkrieg. He collaborates on theatre and animation projects and writes radio plays.
Location Porto, Portugal **Date** 17 January 2013

Florian Cramer



Reader in communication design, and Director of the Piet Zwart Institute, Willem de Kooning Academy, Rotterdam. He is an academic and non-academic writer on arts and media.
Location Porto, Portugal
Date 8 February 2011

Francisco López



Avant-garde experimental musician and sound artist. First Prize for the Sound Art Competition of the Museo de Arte Contemporáneo de Castilla y León in 2006; Three honourable mentions of the Prix Ars Electronica 1999, 2002 and 2007.
Location London, UK
Date 6 July 2010

Frank Zöllner



PhD in computer science, member of the IEEE Computer Society and the European Society for Magnetic Resonance in Medicine and Biology. Leads the research group MRI and Pattern Recognition at Heidelberg University.
Location Lisbon, Portugal
Date 5 October 2012

Franziska Windisch



Artist and composer, lives and works in Cologne and Brussels. The recording of movement in time and space is investigated in her audio-visual installations, concerts and site-specific performances. **Location** São Paulo, Brazil
Date 20 July 2011

François Wunschel



Architect, video mapping expert, founder of the 1024architecture collective.
Location São Paulo, Brazil **Date** 20 July 2011

Gillian C. Smith



Interaction Designer. Was the Professor and Head of the Department of Computer Related Design at the Royal College of Art, London, and the Director of Interaction Design Institute Ivrea, Italy
Location Funchal, Portugal
Date 25 January 2011

Gregory Taylor



Mixologist, producer, performer, visual artist. Works for Cycling '74. Studied gamelan and electroacoustic music in the The United States and the Netherlands wrote for Wired, Recording, Array, and Option. Hosted RTQE radio programme of contemporary audio on WORT-FM since 1986.
Location Hilversum, Netherlands
Date 11 May 2010

Heitor Alvelos



Cultural operator, designer, media culture researcher.
Location Porto, Portugal
Date 24 November 2010

Herwig Turk



Artist. Founding member of HILUS – intermedia Project research Vienna. Founding member of the inclination group vergessen. Artist in Residence at the IMM (Communication and Training Unit and the Cell and Molecular Neuroscience Unit).
Location Porto, Portugal **Date** 17 May 2012

Ian Wojtowicz



Student at MIT, visual artist, exhibited in Paris, Vancouver, New York, Hong Kong, Chicago, Cyprus and Istanbul. Software engineer, his work has twice been featured in Wired Magazine and has contributed to the garnering of Gemini, Emmy and Webby award nominations.
Location: London, UK
Date: 6 July 2010

Ignasi Esteve i Bosch



Artist and landscaper. His work explores the relations between art, neuroscience and synesthesia.
Location Mecina, Granada, Spain
Date 26 July 2011

Ivan Franco



Graduated in Environmental Engineering and MSc in Digital Arts. R&D Director for YDreams in the fields of interactive and ubiquitous computing. Electronic musician and digital artist.
Location Covilhã, Portugal
Date 8 April 2010

Ivan Purpriev



Senior Research Scientist in interactive technologies and interface design at Walt Disney Research, Pittsburgh, USA.
Location: Funchal, Portugal
Date 25 January 2011

Jade Walker



UT Austin – Director of the Creative Research Laboratory, Curator of the Courtyard Gallery at AT&T Executive + Education and Conference Centre, Lecturer for the Department of Art and Art History in the College of Fine Arts.
Location Covilhã, Portugal **Date** 8 April 2010

Janez Janša



Born as Davide Grassi, conceptual artist, performer and producer. Co-founder and director of Aksioma – Institute for Contemporary Art, Ljubljana.
Location Ljubljana, Slovenia
Date 12 September 2012

Jan Kampshoff



Architect, Member of the Convention of the Konvents der Bundesstiftung Baukultur 2010 and of the Architektenkammer NRW. Founder of Modulorbeat – ambitious urbanists and planners.
Location Porto, Portugal
Date, 2 April 2011

Javier Dominguez Muñino



Researcher and professor of aesthetics and art theory at the University of Seville. Lectures on the phenomenology of aesthetic perception and research on the visual territory of nanoart.
Location: Mecina, Granada, Spain
Date: 26 July 2011

Jean Claude Risset



Composer and researcher in sound and computer music.
Location Porto, Portugal
Date 4 June 2011

Jesse Allison



Sonic and installation artist who explores the confluence of technology, interaction, and sound. Co-founder of Electrotap. Virtual Worlds Research Specialist through the Institute for Digital Intermedia Art (IDIA) at Ball State University.
Location Indianapolis, USA
Date 24 April 2010

Joe Osmond



Multi-sensory Artist. Improvises in sound and abstract animation. Member of Equity – Trade Union representing artists from across the entire spectrum of arts and entertainment.
Location: London, UK
Date: 6 July 2010

John Kormeling



Architect, visual artist, architecture, urban and rural planner, designer. Author of the 'Dutch Pavilion' at World Expo 2012 in Shanghai.
Location: Porto, Portugal
Date: 17 May 2012

John S. Gero



Research Professor at Krasnow Institute for Advanced Study. Adjunct Professor Creativity and Cognition Studios University of Technology, Sydney. Formerly Professor of Design Science.
Location: Aveiro, Portugal
Date: 24 September 2010

John Toenjes



John Toenjes is Music Director of the University of Illinois Urbana-Champaign Department of Dance, and President of the International Guild of Musicians in Dance.
Location Indianapolis, USA
Date 24 April 2010

Jolanda Vanderwal



Associate Professor at College of Letters and Science, University of Wisconsin, Madison. Specialist in Dutch and German culture and literature and culture.
Location Amsterdam, Netherlands
Date 14 May 2010

Jordan Munson



Musician, percussionist, composer, and multimedia artist. Member of the Donald Tavel Arts and Technology Research Centre. Founded the Computer Laptop Music Ensemble at Indiana University Purdue University Indianapolis (IUPUI) where he serves as a Lecturer in Music Technology. **Local** Indianapolis, USA
Date 25 April 2010

Joshua Tuthill



Computer graphics and digital art student at Indiana University Bloomington Fine Arts.
Location Indianapolis,
USA **Date** 24 April 2010

Karsten Schmidt



Karsten Schmidt (aka toxi) is a London-based computational designer merging code, design, art, and craft skills. Explores possibilities at the intersection of design, art, software development, and education and applying these in a variety of fields.
Location: Porto, Portugal
Date 14 July 2010

Ludovico Pratesi



Art curator and art critic. Art Director of Fondazione Guastalla and scientific curator at Palazzo Fabroni di Pistoia. Consultant at Associazione Musei Arte Contemporanea Italiani
Location: Cosenza, Italy
Date: 7 May 2012

Marcelo Campos



Art curator and critic, professor in the Theory and History of Art department at the University of the State of Rio de Janeiro. Organiser of the book 'History of Art: Contemporary Essays'.
Location Porto, Portugal
Date 16 May 2012

Marc Günnewig



Architect, Professor at Münster School of Architecture and Kassel University. Founder of Modulorbeat – ambitious urbanists and planners.
Location Porto, Portugal
Date 2 April 2011

Margaret Dolinsky



Associate Professor School of Fine Arts; Research Scientist Pervasive Technology Institute; Fellow Institute of the Digital Arts and Humanities
Location Indianapolis, USA
Date 25 April 2010

Marina Chernickova



Multimedia artist living in Amsterdam and Moscow. MFA in painting from Moscow State Fine Art Academy and Master of Media Arts from the University of Portsmouth. Explores the kinetic visual structures of megalopolises of various cultural traditions.
Location Amsterdam, Netherlands
Date 9 May 2010

Mark Baldridge



Professor of Art B.S., State University of Buffalo. M.F.A., Cranbrook Academy of Art. VR and Immersive Environments developer.
Location Indianapolis, USA
Date 25 April 2010

Mark D. Gross



Professor, teaches tangible interaction design and directs the Computational Design Laboratory in the School of Architecture, Carnegie Mellon University, Pittsburgh, Pennsylvania, USA.
Location Funchal, Portugal
Date 25 January 2011

Martin Kaltenbrunner



Professor at the Interface Culture Lab, University of Art and Industrial Design in Linz. Co-founder of Reactable Systems. **Location** Funchal, Portugal
Date 24 January 2011

Matthew Roberts



New media artist specialising in real-time performance and new media applications. Founder of MPG: Mobile Performance. Associate Professor of Art and Digital Arts at Stetson University.
Location Indianapolis, USA **Date** 25 April 2010

Matthias Kispert



Composer and artist working in London. Since 2004, member of the media arts collective D-Fuse. Member of the experimental music group Crowd Formation. **Location** Porto, Portugal
Date 12 September 2010

Michael Drews



Composer of contemporary acoustic and electronic music, Assistant Professor of Music at Indiana University-Indianapolis. **Location** Indianapolis, USA
Date 23 April 2010

Michael Haverkamp



PhD in acoustics engineering, researches the influence of vibrations in human bodies. Develops multi-sensory design concepts. Author of the book 'Synästhetisches Design – Kreative Produktentwicklung für alle Sinne'.
Location Almeria, Spain **Date** 16 February 2012

Michael Rhoades



Composer and theorist in the area of electroacoustic and computer music.
Location Indianapolis, USA **Date** 25 April 2010

Mike Harding



Curator & Producer; Lecturer & Publisher; Author & Editor; Moderator; occasional exhibitions/installations/performances.
Has been running Touch for nearly 30 years, with Jon Wozencroft.
Location Porto, Portugal
Date 15 October 2010

Miroslav Spasov



Composer of instrumental and interactive electroacoustic music. Professor of electroacoustic composition and computer music techniques at Keele University. His work has received several international awards.
Location Karlsruhe, Germany
Date 8 July 2012

Nathan Seidle



Chief Executive Officer at SparkFun Electronics, expert in embedded electronics. Designs and builds electronic devices (breakout boards, evaluation boards, etc.).
Location Funchal, Portugal
Date 24 January 2011

Nathan Wolek



Music Director of Mobile Performance Group, Assistant Professor of Music at Stetson University, Ph.D. in Music Technology at Northwestern University, VST plugins and Max/MSP externals developer. Co-developed with Electrotap, Hipno, released by Cycling '74 in 2005.
Location Indianapolis, USA
Date 25 April 2010

Nick Ramsey



Professor in Cognitive Neuroscience at the University Medical Centre Utrecht and Professor in Cognitive Neuroimaging at Utrecht University. Leads a research programme on brain-computer interfacing and new functional imaging methods, including high-field MRI.
Location Lisbon, Portugal
Date 5 October 2012

Pedro Mexia



Writer and literary critic.
Location: Porto, Portugal
Date: 27 September 2012

Pedro Rebelo



Professor at School of Music and Sonic Arts, Queen's University Belfast. Composer/digital artist working in electroacoustic music, digital media and installation.
Location: London, UK **Date**: 6 July 2010

Philip Auslander



Researcher in performance, especially in relation to music, media, and technology. Author of five books and editor of two collections. Professor, School of Literature, Communication, and Culture at Georgia Institute of Technology.
Location: Porto, Portugal
Date: 12 October 2010

R. Luke Dubois



Composer, artist, and performer. Co-author of Jitter, a software suite for the real-time manipulation of matrix data.
Location: Indianapolis, USA
Date 23 April 2010

Richard Dorfmeister



Musician, producer and DJ.
Location Porto, Portugal
Date 6 November 2011

Robert Normandeau



Composer, currently focused on acousmatic music. Professor of Electroacoustic Composition at the University of Montreal since 1999. Winner of two Opus Prizes: 'Composer of the Year' and 'Record of the Year' in 1999. **Location:** Karlsruhe, Germany
Date 8 July 2012

Robin Fox



Audiovisual artist, MFA in Musicology and PhD in Composition at Monash University, Melbourne.
Location Porto, Portugal
Date 11 October 2011

Robin Rimbaud aka Scanner



Electronic musician, writer, media critic, multimedia artist and music producer.
Location Porto, Portugal
Date 3 May 2011

Scott Deal



Professor of Music and Director of the Donald Tavel Arts and Technology Research Centre at Indiana University Purdue University Indianapolis. Percussionist and Intermedia Festival Director.
Location Indianapolis, USA **Date** 24 April 2010

Sean Watkins



Floating Lab Collective
http://www.floatinglabcollective.org/
Location Indianapolis, USA
Date 23 April 2010

Suguru Goto



Composer/performer, inventor and multimedia artist. Considered one of the most innovative and the mouthpiece of a new generation of Japanese artists.
Location: Porto, Portugal **Date**: 12 February 2011

Sylvia Pengilly



Retired teacher of music theory, composition and electronic music. Retired director of the electronic music composition studio at Loyola University, New Orleans. Always fascinated by the correlation between what the ear hears and what the eye sees. **Location** Indianapolis, USA
Date 25 April 2010

Teresa Dilon



Polar Produce – Her artistic practice and research explores the interface between real and virtual environments. She has presented her work all over the world and has published on collaborative creativity, music technology, innovation and design.
Location Covilhã, Portugal
Date 8 April 2010

Thorsten Liebig



Researcher and starter of the openEMS project at the Laboratory for General and Theoretical Electrical Engineering (ATE), University of Duisburg-Essen.
Location Lisbon, Portugal
Date 5 October 2012

Tim Boykett



Mathematician involved in Time's Up, a laboratory for the composition of experimental situations. Assistant Professor at Kepler University in Linz. Researches in the field of nearrings and the relations between theoretical computer science and abstract algebra.
Location Porto, Portugal
Date 2 August 2011

Tim Edler



Co-founder of media facade specialists realities:united. Studied computer science and architecture at the Technical University of Berlin. Graduated as an architect.
Location Berlin, Germany
Date 9 November 2010

Tim Glenn



Associate Professor of Dance at Florida State University. Associate Lecturer at University of Wisconsin-Madison. Former member of the Nikolais and Murray Louis Dance Company.
Location Indianapolis, USA **Date** 25 April 2010

Tim Olden



Interaction Designer. Master of Arts in Interactive Multimedia. Founding member of Blendid (www.blendid.nl).
Location Amsterdam, Netherlands
Date 13 May 2010

Timothy B. Layden



Originally from Seattle, Washington, USA, he has been an artist, student, designer and teacher living in the USA, Mexico, Italy, Japan, Spain and the UK. He produces mixed media art and is a PhD candidate studying interdisciplinary art and synesthesia.
Location Mecina, Granada, Spain
Date 26 July 2011

Trevor Wishart



Composer and performer specialising in sound metamorphosis and constructing software to make it possible. Giga-Herz Grand Prize in 2008
Location Karlsruhe, Germany
Date 7 July 2012

Victor Parra



PhD in Education Sciences, Professor of Movement Analyses at UPEL-IPB, Culture and Sports Secretary at Aproupel-IPB. Researches the relation of cosmikinesis with art.
Location Mecina, Granada, Spain
Date 26 July 2011

Xosé Lois Gutiérrez



Photographer, critic and writer. Translated writings from Alain Badiou and collaborated with the platforms Sitioweb, Artszin, SalonKritik, Revista de Las Letras, Protexta, ArtNotes and Neo2.
Location Porto, Portugal
Date 16 May 2012

Xurxo Gonzáles



Art historian from the University of Santiago de Compostela, Ph.D. from the UNED. Audiovisual critic for the magazine Tempos Novos. Archivist of audiovisual archives RTVE-Galicia.
Location Porto, Portugal
Date 26 May 2011

WHAT DOES MEDIA MEAN?

... for me media is more just a material... ahh something that I work with, and something that if I decide to work with it I have to understand it and know what it means to use it ...
Takuro Mizuta Lippit aka DJ Sniff

... it starts with creativity and art and design and applications in all forms of communication and personal interaction.
Bruce Pennycook

Media Ahn! All interpretations of facts, or ideas that translate to human beings.
Jade Walker

Media is a product manufactured by human beings for perception.
David Mc Donald

I guess for me the word media is... is almost a sort of synonymous with a word kind of tool and for me media is language, it's the form in a sense or the clay or the material through which we communicate or express something...
Teresa Dilon

Media is a product manufactured by human beings for perception.
David Mc Donald

It's a format for communicating ideas...
Michael Drews

Media is a medium, it is a way of doing things...
R. Luke Dubois

Media means a go between, it's something that goes between one person, event or place and another person, event or place...
John Toenjes

It's a very general term for form...
Christopher Burns

Media is the format or the material you are working with, how you deliver your material to your audience.
Nathatn Wolek

Material you can use to create with.
Matthew Roberts

Media is what comes between people. It can separate them, but it can also help them connect.
Mark Baldridge

Media is essentially anything you can transport in any sort of substance or idea...
Dave Phelps

... a form of entertainment, something I can watch, play with or see, things I can do with, something else that I

have an emotional response, something that I like, something that makes me feel something for it
Joshua Tuthill

Anything that is trying to convey something...
Jesse Allison

It's a way for us to be able to express even more fantastic thoughts than words alone could express.
Scott Deal

Media is the area that a person chooses to express themselves...
Tim Glenn

Media is an element... it's like a piece of something, a piece of a larger puzzle... and by putting these little pieces together, that's how we create culture and communication. **Jordan Munson**

... it's so uncertain now, everything is media.
Marina Chernickova

Media has to do with the way that something manifests itself in the world.
Gregory Taylor

The definition of media should include any tool that amplifies an individual's creative expression... **David Kousemaker**

Media is … in its general sense information that comes in any form…it can come as a stream or be interactive… **Diemo Schwarz**

…it's just the stuff when you open your toolbox, its just the stuff that's in there, that you work with… it can be quite anything.
Tim Olden

Media is the thing that influences the way we look at reality... it's a filter in a way, it helps you to see new things... it's a subjective thing, sometimes it hides and sometimes it shows things.
Daan Roosegaarde

Any mode of communication between human beings...
Jolanda Vanderwal

Media are things that are between us and other meaning […] Media are these active things that transform information from one place to another [...] '
Ian Wojtowicz

Media is like those tools that we use as interfaces with reality and interfaces in communication as well, whatever tools, technological tools we have ahead or we develop in order to do that: interact with rarity and communication with other people.
Francisco López

Media is a kind of material channel through which we can present particular kinds of messages...
Brandon Labelle

It's a question of format with which you can package content...
Matthias Kispert

Media is an environment for externalising thought.
John S. Gero

... anything that helps to shape the way an audience, let's say, perceives something.
Philip Auslander

Media is the hyphen between two people.
Benoit Maubrey

Media is the plural of medium. Medium is the means of carrying on some other thing.
Blaine Reininger

...it is a medium, no matter what it is.
Cildo Meireles

... to think of media in a sense of intermediary or the thing between things. (...) You could call a media a time space refractor.
David Rokeby

For me, media is a kind of technology that allows me to express myself, to communicate my intentions.
Martin Kaltenbrunner

For me, media means anything people experience.
Ivan Purpriev

A medium is something that comes between two things or two communicating entities...
Mark D. Gross

Very literally it means a transmitter ...the notion of media is a problem ... it's imprecise...
Florian Cramer

It can be tools...on a personal sense... there's no reason to define it on a general sense.
Suguru Goto

Media is such a broad concept and pervasive ... something that is increasingly pervasive and stimulating in both positive and negative terms.
Antonio Camurri

Media is a term that describes a certain form of communication between things.
Jan Kampshoff

Media means a kind of intermediate element between one thing and another.
Xurxo Gonzáles

Media is always about the distribution of ideas... media is always about sharing information...
Robin Rimbaud

Media as the way to produce the sensory signals that are supposed to impress the listener or the viewer or the spectator.
Jean Claude Risset

For me, media is everything that comes to you... and tries to communicate a message; it's just a way of transporting the message.
François Wunschel

It meant that it was strongly related to mediating, so as to have something in the middle that did not obstruct what was on both sides but facilitated the flow of ... substances or processes between two sides.
Alexandro Ludovico

In current times, media means to mediate, especially information... and mediating information also means to transform information, to find a level of communication that allows both sides to communicate...
Alexandro Ludovico

Media means mediation, means a step in between certain types of virtual and physical entities.
Daniel Schorno

Media is a very loaded term... I would use the word media to describe forms of communication... it is the means by which we communicate ideas.
Timothy B. Layden

Media means that which is between...advertising, construction and fabrication,... that construct reality. **Tim Boykett**

I link to think in media as material... the extreme of that would be a conceptual artist who has no medium... **Christof Migone**

... is public knowledge
Richard Dorfmeister

Media means a transfer of information via several sensory channels... to transfer information, to transfer experience and sensations.
Michael Haverkamp

The word media means for me the communication between people.
Cretien Van Campen

Media is an instrument, something you can use in a good or bad way. But it's not synonymous with culture... culture is a world of ideas, communication is the way to communicate ideas.
Ludovico Pratesi

For me, media means means. Art has long been interested in the means of execution and production. **Marcelo Campos**

For me, media is one of the vaguest terms I am confronted with... the first thing that comes to mind is the apparatus we use to transmit or express content and ideas...
Andreas Broeckman

Media... all those human devices that are formed from technical systems and are subsequently translated into cultural systems.
Xosé Lois Gutiérrez

Media is an ancient word for me, ...it just changes form.. media for me is more a transmitter or a dynamic process than an aesthetic category.
Herwig Turk

Media represents means, that is, mediations, forms of content circulation...
Bruno Dias

Media is something that transforms or transmits stuff... whatever we want to specify as media will become media.
Miroslav Spasov

Media for me is a very broad concept, but basically it is the vector one can use to achieve a goal...
Janez Janša

The way that technology transmits ideas (...) a format for receiving the aesthetic experience, it certainly affects the aesthetic... it is the aesthetic.
Erik Nyström

Media encompasses all kinds of channels for transferring information (...) just a word that covers everything, I guess.
Frank Zöllner

Media is everything you get information from.
Thorsten Liebeig

WHAT DOES INTERMEDIA MEAN?

... I think the only way we could become inter or hyper or multimedia is actually the moment we could step over it and almost make it invisible or make it, you know, jump out of it.
Takuro Mizuta Lippit aka DJ Sniff

... it's another word to describe this multiplicity of media that can be combined, but I think now with boundaries established in a slightly different way, a little more towards the future.
Ivan Franco

... and intermedia strikes me as pretty much the same thing (multimedia) in other words a collaborative or crossed discipline type of creative activity.
Bruce Pennycook

I suppose intermedia would be subsets of media that interact with each other...
David Mc Donald

It might be an evolution of what multimedia is...
Sean Watkins

For me, the internet is a big part of what makes something intermedia...
Michael Drews

Intermedia is working between things, (...) multimedia is working on a lot of things (...)
R. Luke Dubois

media that collides into other media and affects that media through the collision...
John Toenjes

…perhaps intermedia has a more complex set of influences between the media than multimedia does…' **Christopher Burns**

Multimedia would be two parallel streams of media… Intermedia to me conveys a sense of the two media being interrelated and affecting one another.
Nathatn Wolek

Intermedia usually crosses more boundaries between mediums...
Matthew Roberts

'Where we contact media […] but also enter media, it is also stepping into the media, you become part of the communication and part of the process…
Mark Baldridge

It's the interaction of different media... tightly integrated.
Michael Rhoades

It's basically (...) some place that Evan lands in between (...) or things that blur media...
Jesse Allison

Intermedia refers to the notion of integration and thus synthesis... Intermedia takes that multiplicity but integrates it into a singular thought...
Scott Deal

Intermedia relates to things that are inter-related and interconnected so that there's a blending and a merging of areas that come together... translating into that new definition of what art can be.
Tim Glenn

... is an attempt to work on that idea of making data (data or information in some form) visible...
Gregory Taylor

Intermedia will be more actually the creative part in the process of creating...
Daan Roosegaarde

Intermedia is something where the focus is more on the actual interaction between different media.
Matthias Kispert

Intermedia is the medium that sits between media.
John S. Gero

Intermedia is thus close to the idea of synesthesia, this blending. Multimedia is a plurality of media that are not necessarily interpenetrating.
Cildo Meireles

Intermedia is more about playing with the relationships between media and being quite clear about these different media.
David Rokeby

Of all the words one can use to talk about art, I think interdisciplinary is one of the most useful ones.
David Rokeby

Intermedia suggests interactivity, things happening and things happening back.
Mark D. Gross

Intermedia is a word that attempts to work on the borders of different media, like blurring and connecting thinking... Intermedia is a more integral approach (compared with Multimedia)...
Jan Kampshoff

Intermedia is in between media and multimedia is multiple forms of media... the togetherness of media is nowadays more the form... multimedia is the being next to each other... intermedia is a totally different thing.
Christoph Haag

Intermedia sounds like the intersection of media, how different formats, how different technologies react to each other.
Nathan Seidle

Intermedia, from the Latin, would mean the intersection, the relationship between media... an intertwining... **Alexandro Ludovico**

I would define intermedia as ways in which different forms of communication transfer ideas and through that transference there is translation to a new format.
Timothy B. Layden

Intermedia, I guess, is a conversation between media...
Robin Fox

Intermedia is a suggestion to still negotiate the media...
Intermedia is undecided, it's in between the layers...
Intermedia is more of a process...
Herwig Turk

Multi is the simple observation of its diversity and plurality...
Inter establishes a relationship and a plane of relationality.
Multi comes before Inter. The relationship has a constitutive role...
Bruno Dias

Intermedia first is the movement or the development of artistic work that goes beyond medium specificity.
Andreas Broeckman

Intermedia undoubtedly has important roots in the 1960s and 1970s, which, from my theoretical point of view, is sometimes difficult to deny, in the sense that intermedia art will always be linked in some way to the theories and productions of the 1970s. If we analyse it from this point of view, it is somewhat outdated.
Cláudia Giannetti

Intermedia would be in my opinion something where different practices will interfere with each other...
Robert Normandeau

Intermedia stands for integrating different media... basically using the inter-zone or grey areas that various media give you.
Janez Janša

Intermedia would be, I guess, the language between different media channels.
Nick Ramsey

WHAT IS THE RELATIONSHIP BETWEEN THEORY AND PRACTICE IN YOUR WORK?

I think that I can understand my thinking through acting better than understand my acting through thinking, and that's the same with theory and praxis.
Felix Kubin

You can only find the theory through praxis [theory] is like creating a golden ornament for praxis, but praxis has to come first.
Felix Kubin

I feel that once you are making your work, theory should be a secondary concern.
David Mc Donald

I view theory as a tool […] once you are making your work, theory should be a secondary concern.
David Mc Donald

[Theory and Practice] Both things have to feed each other […] both things have to form each other…
Michael Drews

They effectively deny each other, denying each other day by day until they become monstrous students who do not understand where they stand.
Edgar Endres

For me, theory is something you learn and then forget about...
Matthew Roberts

My theory is that practice comes first... I very rapidly codify and formulate my theory as I work... make the art from what you have rather than conceptualise it first.
Mark Baldridge

...we study, we learn everything we can, but when you are creating, you drop all that and just move with what you are working on.
Michael Rhoades

… they're related, I think there's a kind of a mix…
Joshua Tuthill

…you need theory, you need speculation, you need higher thought, it illuminates the process… it's hard to say what comes first.
Scott Deal

The practice results in the discovery of new theories.
Tim Glenn

Theorising in some way is something we do when we begin, but it is by no means something that constrains the work we do…
Gregory Taylor

The motivation for the work comes out of the practice, for the research and for my own music realisation I try to forget the theory and come to a point where its more experience based..
Diemo Schwarz

(Theory and practice) It's a ping pong, (...) in my practice I look for methods on how to generate complexity and strategies on how to keep simple form.
Daniel Schorno

I'm kind of sceptical about cultural theory... for me theory is something that I typically find difficult to read...
Ian Wojtowicz

My approach is that I'm a very passionate, intuitive, immediate person when it comes to work, and this is first...
Francisco López

They go in parallel, very intertwined, very stitched together...
Brandon Labelle

I very much believe in bottom up in everything...
Karsten Schmidt

In theory, theory and practice are two sides of the same coin, but in practice they are not.
John S. Gero

Theory is usually the part you have to throw out after you have gone into practice.
Benoit Maubrey

In the actual practice of my art I try to make it as theory-free as possible...
Blaine Reininger

I prefer to start when possible from practice...the work usually comes from practice or even more, it comes from experience that is articulated from practice...
David Rockeby

In our work there is typically iterative movement between theory and practice.
Tim Edler

From my personal work, I come from practice to theory. I am a very practical mind, so I like making things... **Martin Kaltenbrunner**

'There's a very famous quote from a very famous scientist... "There's nothing more practical than a good theory." That's what I think about theory.'
Ivan Purpriev

Theory doesn't drive my practice at all!
Mark D. Gross

You can't teach people to design from a book...
Gillian C. Smith

It's intrinsically linked.
Florian Cramer

I do things and while I'm doing them I'm finding the reason why I did them. Completely bottom to top!
Alexander Römer

As an office, we are very much interested in just producing things... it's not a theoretical way... to find an answer... **Marc Günnewig**

There is no theory without practice...
Jan Kampshoff

For me, practice comes first, quite clearly. I don't sit around theorising about my work. First and foremost, it's the work that matters!
Robin Rimbaud

Most scientific theories are perishable...
Jean Claude Risset

Theory is linked to practice; without theory there is no practice, without practice there is no theory, it's just blah, blah, blah.
François Wunschel

They go in parallel, constantly influencing each other.
Christoph Haag

Theory... it's much better if it relates to some practice, it sounds much less abstract, it really relies on something that has happened, not only on something that has been conceived...
Alexandro Ludovico

In theory there is no difference between theory and practice, but in practice there is.
Tim Boykett

I don't really make a distinction between the two because I think of theory as thinking and practice as also thinking... thinking as practice...
Christof Migone

A theory must always be practical
Cretien Van Campen

They are paradoxically related.
Xosé Lois Gutiérrez

Usually I feel totally disabled in theory... language represents just a part of what we actually call knowledge...
Herwig Turk

I think theory still has the word theos in it, and I think if you really use your brain you should not use the word that means god...my ideas come out of practice...
John Kormeling

... words and actions... theoretical words and practical actions are two forms of thought... artistic practice is a form of thought, but it thinks through its own means... **Bruno Dias**

...I don't really know what theory is and the things that I know about theory I often don't find very interesting because ... it's also a way of thinking that disconnects ideas from ... practice, disconnects ideas from things.
Andreas Broeckman

The theory only comes afterwards; I am a very practical composer.
Robert Normandeau

In general, I would say that theory was never prevailing, it was never before and the work of art after... **Janez Janša**

I would like to think that there is no difference between theory and practice.
Erik Nyström

Theory holds me back, it's a shackle...
Pedro Mexia

In practice, you realise that not everything you think is possible in theory will actually be possible to do.
Frank Zöllner

OTHER RESEARCH RESULTS

As mentioned above, only written documentation explaining the process of designing and developing four of the works resulting from the reflective practical research carried out in this doctoral thesis has been produced. However, this research has resulted in other works, objects and experiences. Some of these results have been documented and will be referred to in the following pages. Other results exist as material for future approaches.

KEPHOISE 2012

Kephoise[476] is an experiment in visualising and sonifying electrical voltage fluctuations in the human scalp. The name of this work is a contraction of the Greek term *kephalos*, meaning head, and the English term *noise*.

The creation of this work was triggered by an invitation made to the artist by the Manuel António da Mota Foundation [477] to participate in [the] *Tangible Feelings* Workshop [478] led by Mattia Casagleno. For this work, an experimental computer programme was developed that converts data digitised by the *Emotiv* EPOC EEG device into sound and visual events synthesised in real time. This programme integrates [particle] systems and [white] noise generators that are modelled by oscillators, which in turn are controlled by the electrical activity on the users' scalps.

We suggest consulting the [audiovisual] documentation[483] of the work for a better understanding. Each user corresponds to a particle system and a white noise generator. The particles in each of these systems are drawn in a different colour: yellow for user *A* and blue for user *B*. The particles are synthesised in real time by the computer using [OpenGL] commands. Visualised in a video projection, the particle systems oscillate in a horizontal movement. This movement is determined by two sinusoidal waves, generated by two oscillators, which respectively determine the abscissas of each system

476 http://3kta.net/3kephoise.php

477 http://www.artes.fmam.pt/

478 http://tangible-feelings.wikispaces.com/

479 Electroencephalogram.

480 http://www.emotiv.com/epoc/

481 http://en.wikipedia.org/wiki/Particle_system

482 http://en.wikipedia.org/wiki/White_noise

483 https://vimeo.com/54086998

484 http://www.opengl.org/about/

of particles. The digitised data of the electrical voltage on each user's scalp controls the frequency of each oscillator respectively. In other words, the greater the electrical activity, the faster the particle systems oscillate and the larger their size. Simultaneously, the abscissa value of each particle system controls the sound panorama generated by the two white noise generators respectively.



Figure 73. Kephoise work with performers Francisco Teixeira and Horácio Tomé using the *Emotiv EPOC* interface. André Rangel 2012.

The dissemination of audiovisual documentation led Dr. Luís Gustavo Martins, then Director of the Sound and Image Department and Deputy Director of CITAR at the Portuguese Catholic University, to invite researcher André Rangel Macedo to introduce a student whose master's project involved 'measuring brain activity'. Following this invitation and even before the presentation, based on the knowledge acquired in the research that resulted in Kephoise and previous research, as well as supported by Kosslyn's writing

(1994), the researcher informally expressed his point of view regarding EEG devices by email.

485 'I am available to talk at UCP next week if it suits you; I am completely flexible.

I can already provide some information regarding my point of view and personal knowledge on this subject. Without wanting to claim that it is 'pseudo-science', and without forgetting the principle that when we observe, we alter what is observed, my scepticism is 'enormous' ;). The credibility that EEG devices inspire in me is on a par with the credibility that the classic and 'obsolete' polygraph test inspires in me, which has already condemned many people.

I had my first experiences with so-called 'EEG' devices in 2001 together with Tina Auer and Tim Boycket from 'Time's Up' using the IBVA (http://www.ibva.co.uk/). At that time, we concluded that it was impossible to control anything intentionally. We found that there was a lot of noise in the signal, mainly caused by the 'electric smog' produced by all the devices in the laboratory (computers, transformers, loudspeakers, amplifiers, video projector, radio transmitter/receiver and mobile phones). Recent specific literature points to further weaknesses of the EEG, such as the difficulty in locating the source of electrical activity, or the distortion caused by the skull, which, because it is not of constant thickness, causes a very heterogeneous distortion of the electrical current.

More recently, in October 2012, I participated (as a student/visitor) in the http://www.esmrmb.org/index.php?id=/en/index/esmrmb_2012_congress.htm (ESMRMB) Congress in Lisbon. I believe it to be one of the most important events worldwide on magnetic resonance imaging. My interest in this congress was precisely to learn about the state of the art in visualising/analysing brain activity and the various levels of coding from data capture to image production. It seemed to me that the MRI approach and especially fMRI (with contrast fluid injection) allow for the most interesting images. Perhaps because they are the most recent techniques, I believe they are preferred by neuroscientists. However, there is also recent literature that questions the work of neuroscientists who base their studies and theories on these images (which 'represent' 'areas of brain activation'). In other words, considering an area of activation in the brain, no one can guarantee that this activation represents an excitatory or inhibitory process. A basic speculation: we see an object and an area of the brain is activated. No one can guarantee that this activation represents concentration, focus on that object, or whether, on the contrary, this activation represents the subtraction of all information that is not the object. It cannot be guaranteed that the activation occurs in one place (in the brain) or whether it is an indirect consequence of events in another place. Nor has it been proven that the greatest blood flow (in the brain) occurs where there is the most processing. Well, these and other opinions make me sceptical, let's say 50-50.

According to experts, all techniques for 'observing' brain activity have 'strengths' and 'weaknesses'. In fact, 'EEG' devices are the cheapest and therefore the most accessible for civil or individual use. I have a Myndwave mobile also from Neurosky. At Kephoise and EegSpiral, I used two EPOC Neuroheadsets from Emotiv (http://www.emotiv.com/store/headset.php) that were lent to me by Mattia Cassa-gleno, costing between $299 and $750. I only had a couple of days' experience with these headsets and, based on my ignorance and my 50-50 scepticism, it seems to me that these devices measure electrical activity on the scalp and not exclusively cerebral electrical activity. It is 'common sense' that differences in blood flow can cause different levels of electrical resistance. In other words, the Emotiv headset is very effective at detecting whether you blink your left or right eye (muscular activity, not brain activity). The state of meditation/relaxation (which the manufacturer claims can be measured) is usually achieved with your eyes closed or your face very still. Once again, it seems to me to be more a measurement of electrical resistance variation caused by muscle activity/inactivity than anything else.

Emotiv also has software for training and moving objects in OpenGL space. This software integrates learning algorithms and allows the entire system to be calibrated. I could describe and comment on my brief experience with the system in a few more lines, but I will save some typing and save some topics for our meeting ;)

Despite everything, I consider EEG devices to be excellent for integrating and influencing audiovisual creation, composition and expression systems, so I am optimistic about their use in art. Possibly with more time dedicated to experimenting with the EMO-TIV headset, I would form a different opinion. I hope that these words (the result of my ignorance) are of some use and motivate Vasco Pucarinho to develop work and knowledge that, from a very selfish perspective, will help me to destabilise this 50-50 'limbo' :)' (Macedo, 2013)

EEGSPIRAL 2012

Eegspiral[486] is the result of practical reflective research carried out in this PhD using the Emotiv EPOC[487] EEG interface. In this work, while the user listens to a two-minute musical composition, the electrical activity of the user's scalp disturbs the curve of a spiral. The computer programme designed for this work draws three concentric spirals from the centre to the periphery. Simultaneously, the programme plays a sound file with a musical composition of the same duration. To participate in the work, a member of the audience places the Emotiv EPOC device on their head. The electrical activity on the user's scalp is digitised in real time and disturbs the regularity of the spiral that is being drawn in real time. At the end of each listening session, the programme saves the resulting image in vector format on a computer hard drive.

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486 http://3kta.net/3eegspiral.php

487 Electroencephalogram.

488 http://www.emotiv.com/epoc/



Figure 74. EegSpiral. André Rangel 2012.

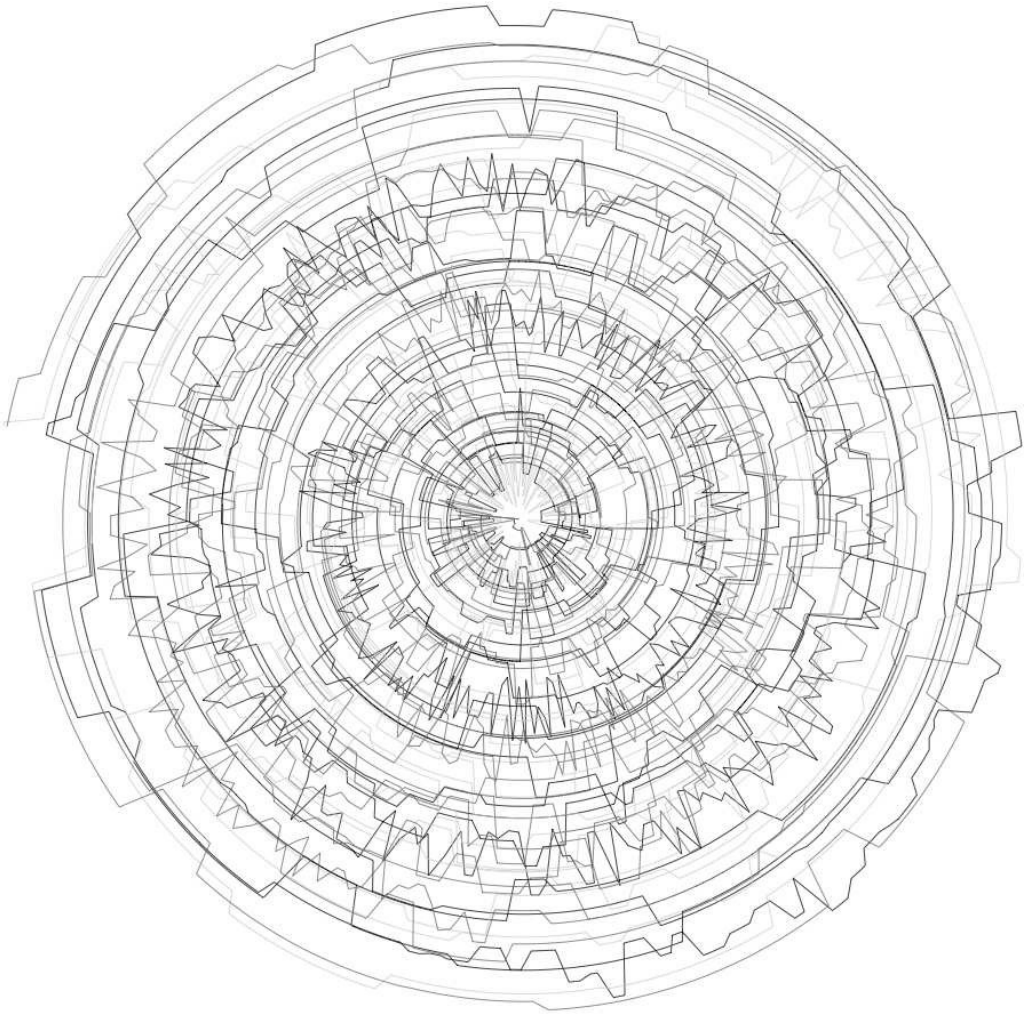

Figure 75. EegSpiral. André Rangel 2012.

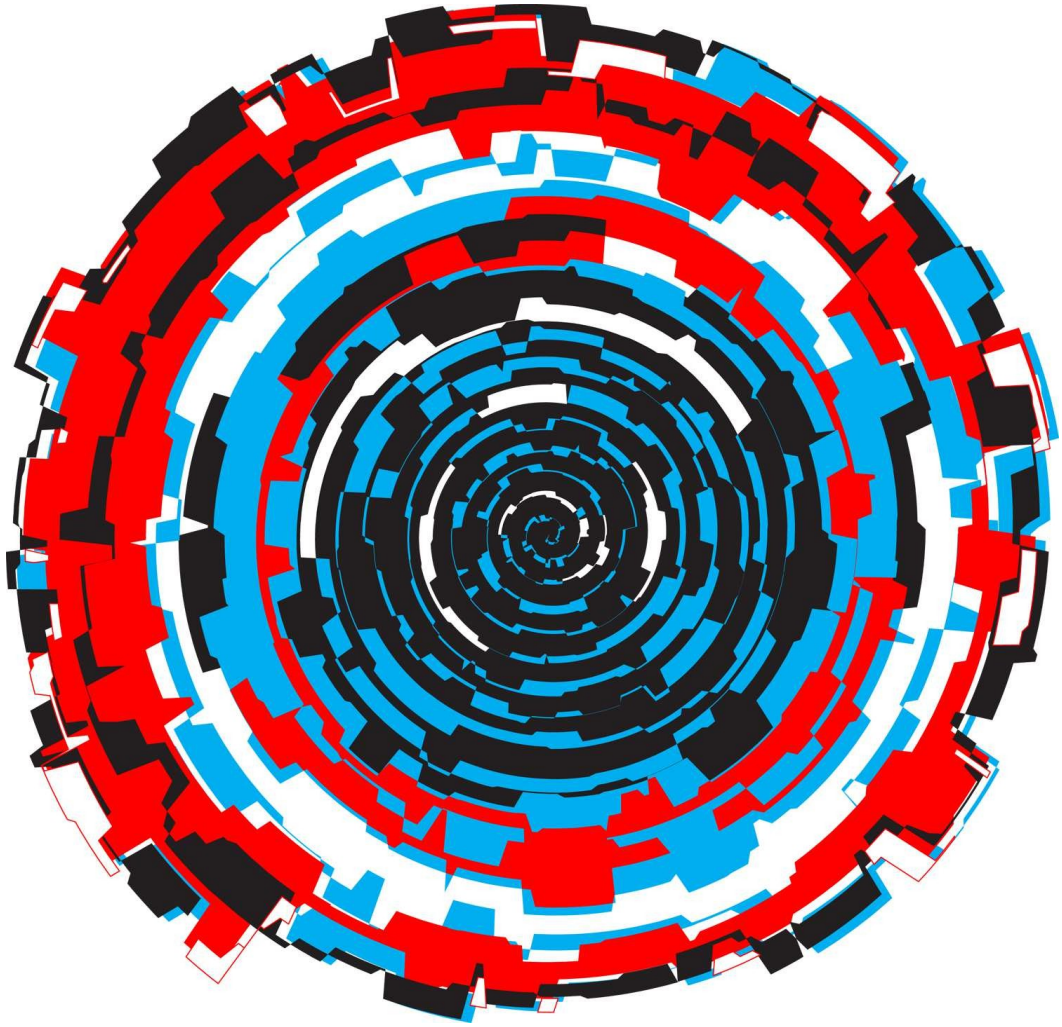

Figure 76. EegSpiral — variation with colour. André Rangel 2012.

OAV 2012

OAV[489] is a multimodal performance system operated by André Rangel in the visual domain and by Miguel Carvalhais[490] and Pedro Tudela[491] in the sound domain. The OAV work was not designed as a stand-alone installation, but rather as a performance tool to be developed in co-processing with human operators. The structure of OAV is generative, with results ranging from minimalism to extreme noise, progressing from a high level of abstraction and very slow tempo to the almost figurative, with a progressively accelerating rhythm.

This artistic object simultaneously uses generative and procedural methods in real time: 1) a noise generator based on pseudo-random value matrices; 2) procedural models that generate visuals and sounds of arbitrary resolution and open variation; 3) incorporation and re-processing of data collected from the physical world. The sound layer is created from the integration of algorithmic processes, field recordings and synthesis, partly automated and partly operated live with computational tools. The visual processing technique is based on algorithms that generate coordinates on a Cartesian grid, which is transformed by rotation and translation. The algorithm uses coherent, pseudo-random mathematical functions to create texture and modify geometry. The visual results are reminiscent of the imagery of the nanoscopic world. This situation did not result from an aesthetic influence or a conscious decision, but rather from a similarity discovered after the image generation processes had been designed and programmed. In addition to the plastic and structural similarities, the processes use high levels of encoding, meta-encoding and transcoding techniques.

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489 http://3kta.net/3oav.phphttp ://vimeo.com/32110371

490 http://www.carvalhais.org/

491 http://pedrotudela.org/

that make synthetic systems resemble chemical and biological entities.

In addition to presentations in Porto and Lisbon, this work was selected and included in the [ICMC492] 2012 programme.

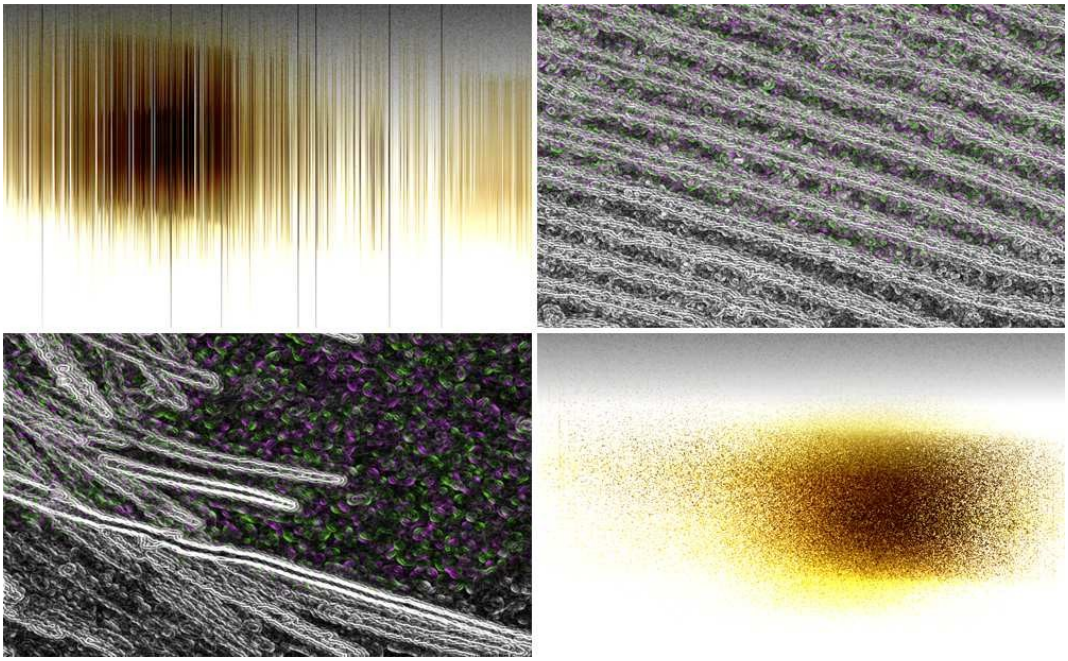

Figure 77. Images recorded during rehearsals for the work. André Rangel 2012.

492 http://www.icmc2012.si/program.html

LUXAETERNA 2012

At the suggestion of the supervisor of this PhD project, Dr. Paulo Ferreira Lopes, a collaboration was proposed with Dr. Pedro Monteiro, who at the time was developing a study on the musical composition of György [Ligeti's] work Lux Aeterna. This collaboration resulted in the design of a musical information visualisation system consisting of a computer executable programme.

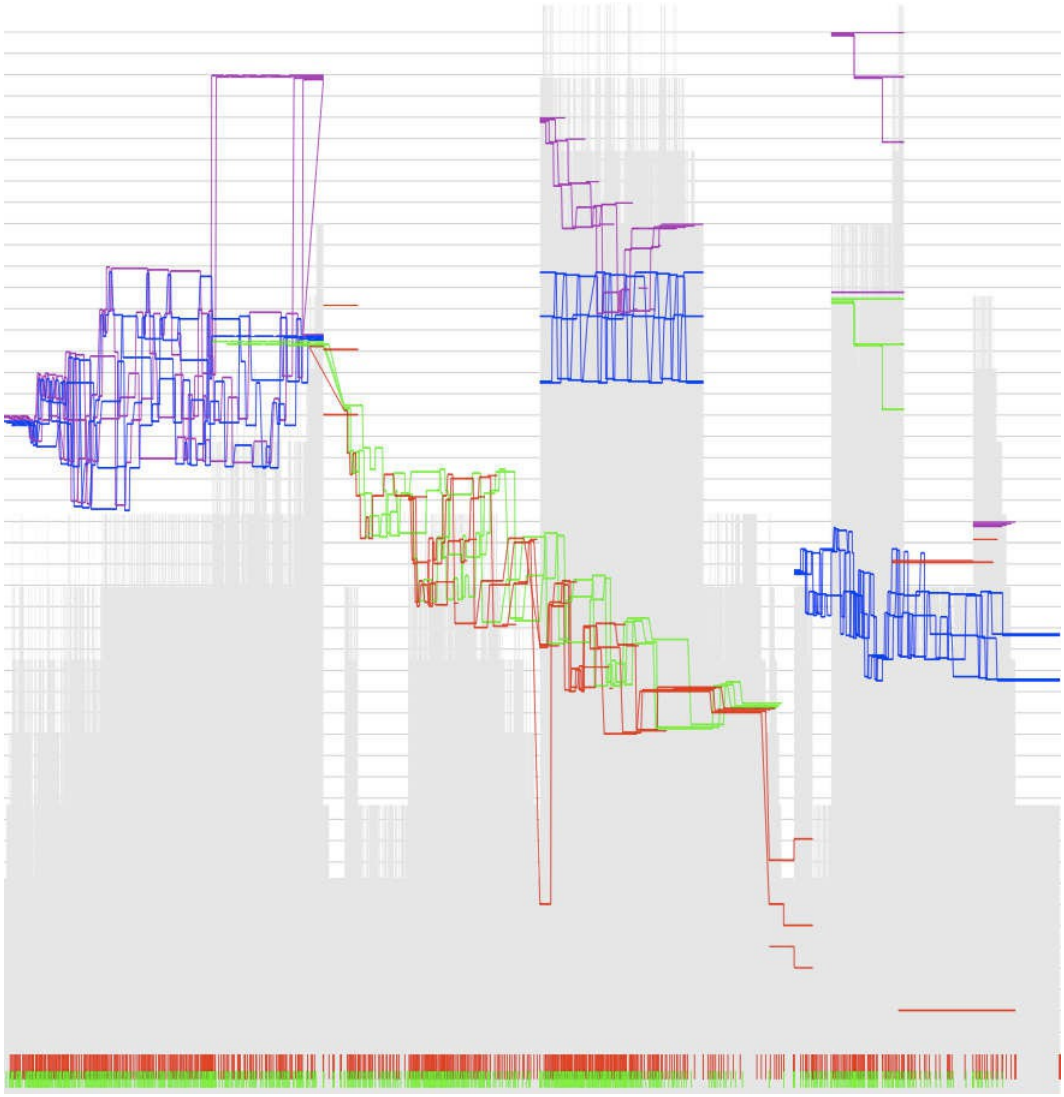

Figure 78. Image resulting from the analysis of the musical composition. André Rangel 2012.

493 MONTEIRO, Pedro M. P. - *Order, chaos and perception. Theoretical and analytical model for Gyorgy Ligeti's "Lux aeterna".* Doctoral thesis in Science and Technology of the Arts. School of Arts. Portuguese Catholic University - Porto, 2013.

494 1923-2006

The work Lux Aeterna is sung by 16 voices, 4 sopranos, 4 altos, 4 baritones and 4 tenors. The programme generates a vector image that simultaneously represents: the musical pitches of each of the 16 voices performing Lux Aeterna, the duration of each voice's singing, the number of voices singing simultaneously, and all the moments when a voice begins or stops singing. Each of the 4 voice groups is represented by a different colour. The musical pitch is represented on the vertical axis of the drawing and the duration on the horizontal axis. The number of voices singing at a given moment is represented by a grey patch that serves as the background of the drawing. At the bottom of the drawing, all the moments when all the voices begin or stop singing are marked.

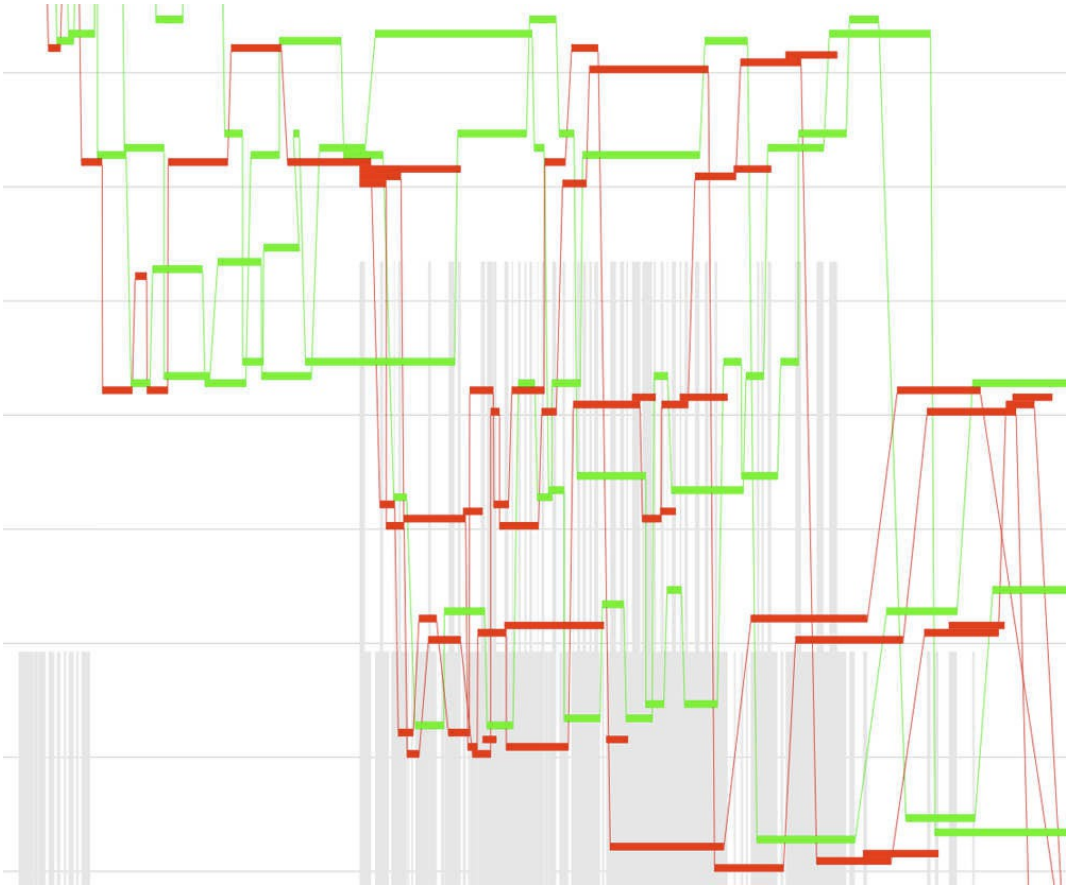

Figure 79. Detail of the resulting image. André Rangel 2012.

FORFLUSSER MAY 2011

At the invitation of philosopher Dirk Hennrich, co-editor of the journal *Flusser Studies*[495], to celebrate the 90th anniversary of Vilém Flusser's[497] birth, a contribution was prepared for the May 2011 issue of this journal[496]. This contribution consisted of an article[498] and a collection of images, calculated by a computer programme specially designed for this purpose. The aim was to produce digital images that approximated Flusser's vision of technical images. To this end, the code of the work AutomatD[499] by researcher André Rangel, produced in 2004, was revisited. This code was updated to calculate this set of exclusive images. These images have no referent and are generated through calculations performed by the computer programme using an original three-dimensional modelling process. The programme explores the concept of *objectile*[500] as an event of modelling form in time, of continuous variation of form (Macedo, 2005). The images that make up this tribute to Flusser are merely records of moments of *the objectiles*.

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495 http://www.flusserstudies.net/pag/editorial.htm

496 http://www.flusserstudies.net/pag/archive11.htm

497 1920–1991

498 http://www.flusserstudies.net/pag/11/macedo-for-flusser.pdf

499 http://3kta.net/3automatd904.php; http://3kta.net/3automatdxl.php; http://3kta.net/3automatd704.php;

500 http://www.virose.pt/vector/b_12/rangel.html



Figure 80. Instant of *the objectile*. André Rangel 2012.

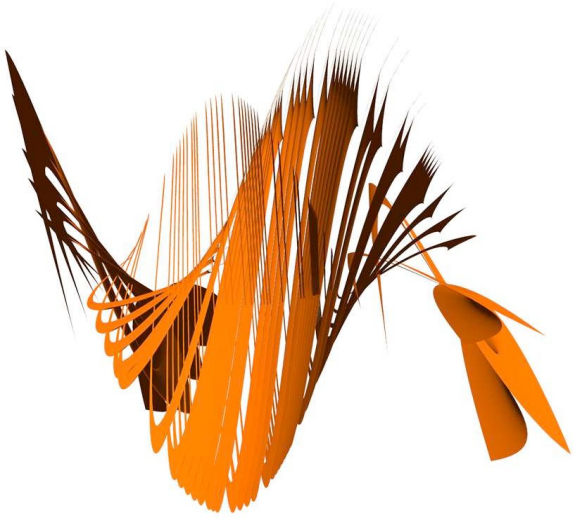

Figure 81. Instant of *the objectile*. André Rangel 2012.

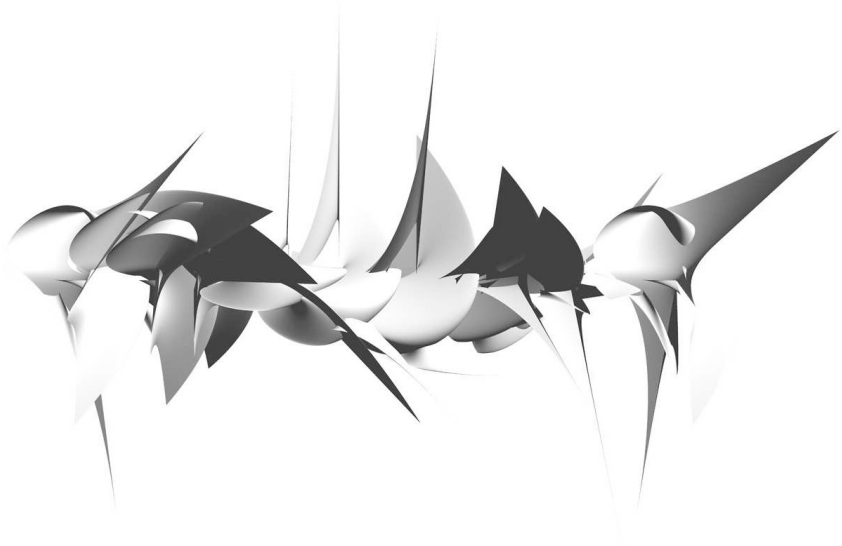

Figure 82. Instant of *the objectile*. André Rangel 2012.

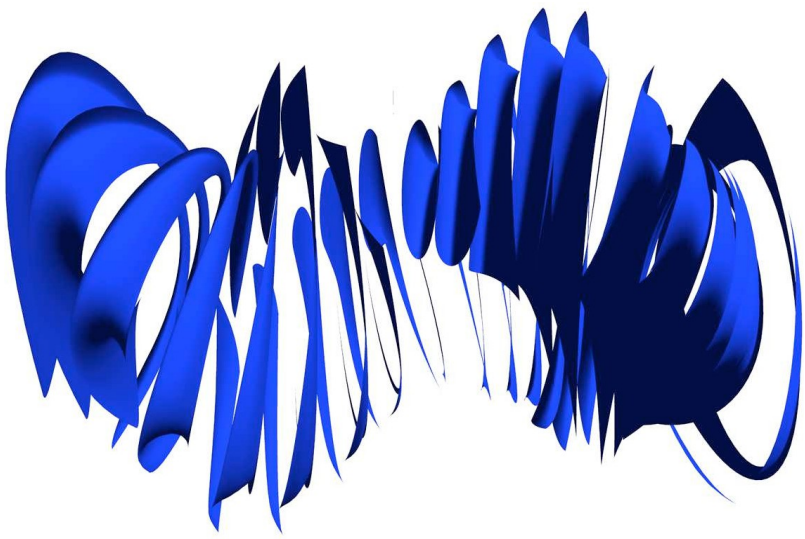

Figure 83. *Objectile* moment. André Rangel 2012.

PROVERB JUNE 2011

At the invitation of the supervisor of this research project, Dr. Paulo Ferreira Lopes, a piece of software was developed for real-time visual synthesis, designed exclusively for an interpretation of Steve Reich's work *Proverb*. Operated by André Rangel, the visuals generated by this software accompanied the interpretation of *Proverb,* conducted by maestro Pedro Monteiro, which included two vibraphones, two synthesizers and five singers. This event was part of the project to *make the musical estate of maestro Ivo Cruz available to the community* at the Portuguese Catholic University.

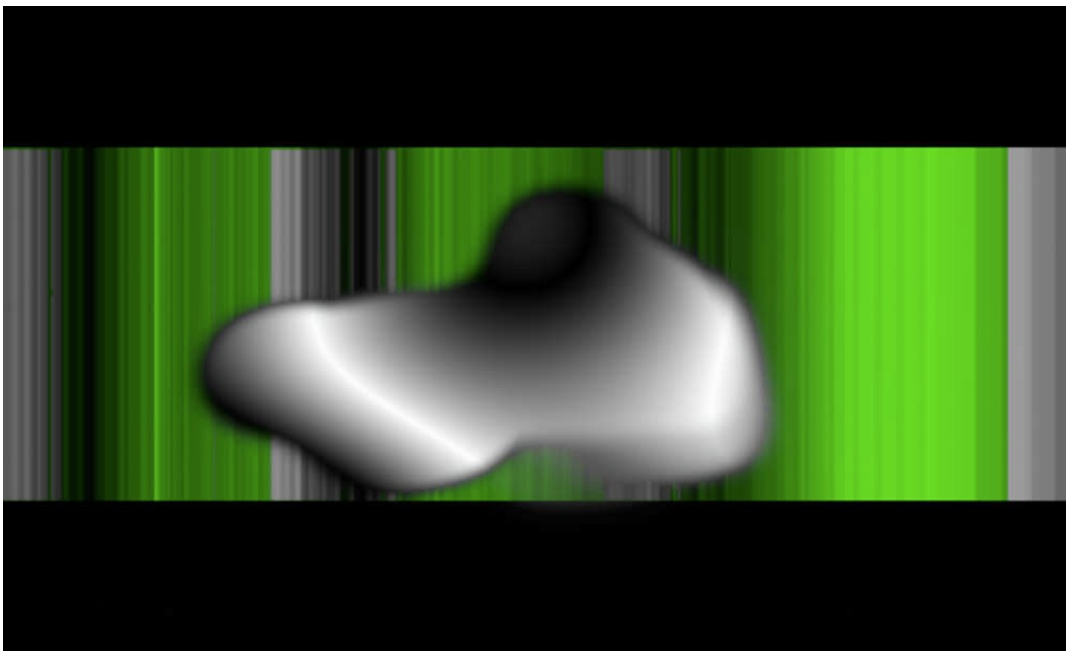

Figure 84. Moment during the performance of *Proverb*. André Rangel 2011.

BIBLIOGRAPHY

Abbott, A. (2001). *Chaos of Disciplines*. University of Chicago Press.

Abrams, M. H. (1974). Belief and the suspension of Disbelief, 1957. In *Literary Criticism--Idea and Act: The English Institute, 1939-1972: Selected Essays* (pp. 149–169). University of California Press.

Acharya, S., & Shukla, S. (2012). Mirror neurons: Enigma of the meta-physical modular brain. *Journal of Natural Science, Biology and Medicine*, *3*(2), 118_124. doi:10.4103/0976-9668.101878

Alexenberg, M. (2011). *The Future of Art in a Postdigital Age: From Hellenistic to Hebraic Consciousness* (2nd edition). Intellect Ltd.

Amundson, R. (1996). Historical Development of the Concept of Adaptation. In M. R. Rose & G. V. Lauder (Eds.), *Adaptation* (1st edition, p. 511). Academic Press.

Annas, J. (2011). Practical Expertise. In J. Bengson & M. A. Moffett (Eds.), *Knowing How: Essays on Knowledge, Mind, and Action* (pp. 101–113). Oxford University Press.

Archer, B. (1995). The Nature of Research. *Co-Design, Interdisciplinary Journal of Design*, 6–13.

Armitage, J. (2002). Introduction. In *Art and Fear*. Continuum.

Arsenault, D., & Bonenfant, M. (2012). Poiesis and Imagination in the Aesthetic Experience: The Moment of Grace in Computer Game Play. In *The Philosophy of Computer Games*. ArsGammes - Games Studies & Art Group.

Ascott, R. (2013). *Interstitial creativity: art, mind and technology*. Presented at the COST Arts and Technologies Workshop, Zagreb, Croatia. Retrieved from http://www.cost.eu/download/41192

Attar, H. (2010). *The Dance on the Feet of Chance - Handling Uncertainty and Managing Risk in the Fuzzy Front-end of Innovation*. Xlibris.

Austin, T. R., Rauch, A., Blau, H., Yudice, G., van Den Berg, S., Robinson, L. S., … Traub, V. (1996). Defining interdisciplinarity. *Publications of the Modern Language Association of America*, 271–282.

Azar, B. (2005). How mimicry begat culture. *Monitor on Psychology*, *36*(9), 54.

Baker, G. (2003a). Entr'acte. *October*, *105*, 159–165. Baker, G.

(2003b). Reanimations (I). *October*, *104*, 28–70.

Bandt, R. (2006). Sound installation: Blurring the boundaries of the Eye, the Ear, Space and Time. *Contemporary Music Review*, *25*(4), 353–365. doi:10.1080/07494460600761021

Bang, A. L., Krogh, P. G., Ludvigsen, M., & Markussen, T. (2012). The Role of Hypothesis in Constructive Design Research. In *THE ART OF RESEARCH IV Making, Reflecting and Understanding*. Aalto University School of Arts, Design and Architecture Helsinki, Finland: Studies in Material Thinking.

Baron, M. (2011, 11 March). Syndyn — Audio/Visual Game Experience. *20 Minutes into the future*. Digital Findings and Technical Oddities. Retrieved from http://20minutesintothefuture.co.uk/?p=427

Barret, S. R. (2002). *Culture Meets Power*. Praeger.

Barth, J. (1984). *The Friday Book: Essays and Other Nonfiction*. Johns Hopkins University Press.

Barton, B. (2008). Subjectivity [] Culture [] Communications [] Intermedia: A Meditation on the "impure interactions" of Performance and the "in-between" Space of Intimacy in a Wired World. *Theatre Research in Canada/Recherches Théâtrales Au Canada*, *29*(1). Retrieved from http://journals.hil.unb.ca/index.php/TRIC/article/viewArticle/11 136

Barton, E. D. (2010). Recent Advances in Further Research on Irreproducible Results: A Generalisation. In E. G. Pavia, J. Sheinbaum, & J. Candela (Eds.), *The Ocean, The Wine, and the Valley: The Lives of Antoine Badan* (pp. 31–62). CICESE.

Benjamin, W. (1999). *The Arcades Project*. (R. Tiedemann, Ed.). Harvard University Press.

Benjamin, W. (2008). The Author As Producer. In M. W. Jennings, B. Doherty, & T. Y. Levin (Eds.), *The Work of Art in the Age of Its Technological Reproducibility, and Other Writings on Media*. Cambridge, Mass.: Belknap Press of Harvard University Press.

Benner, W. R. (2001). Audience Scanning safety article — Making shows safe and enjoyable. Pangolin Laser Systems. Retrieved from http://www.laserist.org/files/Making%20shows%20safe%20and%20enjoyable.pdf

Bennett, J. (2007). Aesthetics of Intermediality. *Art History*, *30*(3), 432–450.

Bennett, P., & O'Modhrain, S. (2007). Towards Tangible Enactive-Interfaces. In *Proceedings of ENACTIVE/2007*. Grenoble, France: Association ACROE.

Bennett, R. (1986). *Form and Structure in Music*. Jorge Zahar.

Berger, R. (1980). Intermedia: Process to a Transculture. In *Theoretical Analysis of the Intermedia Art Form*. Solomon R. Guggenheim Museum, 1980.

Bermudéz, J. L. (2007). *Thinking Without Words*. Oxford University Press, USA.

Biggs, M. A. (2004). Learning from Experience: approaches to the experiential component of practice-based research. *Forskning, Refleksjon, Utvikling-*, *6*(21). Retrieved from http://r2p.herts.ac.uk/mb/2004a.pdf

Biglan, A. (1973). The characteristics of subject matter in different academic areas. *Journal of Applied Psychology*, *57*(3), 195–203. doi:10.1037/h0034701

Birringer, J. (1985). Postmodern Performance and Technology. *PAJ: A Journal of Performance and Art*, *9*(2/3), 221–233.

Birringer, J. (1999). Contemporary Performance/Technology. *Theatre Journal*, *51*(4), 361–381.

Blackmore, S. (2000). *The Meme Machine*. Oxford Paperbacks.

Blumenreich, U., Brown, B., Eversmann, P., Hasan, A., & Zurlo, F. (2009). *Reforming Arts AND Culture Higher Education IN Portugal* (Report of an International Panel of Experts). Portugal: MINISTRY of

SCIENCE, TECHNOLOGY, and HIGHER EDUCATION, PORTUGAL. Retrieved from http://www.mctes.pt/archive/doc/Final_A_C_Report.pdf

Bongers, B. (2000). Physical Interfaces in the Electronic Arts - Interaction Theory and Interfacing Techniques for Real-time Performance. In M. M. Wanderley & M. Battier (Eds.), *Trends in Gestural Control of Music*. Ircam - Centre Pompidou.

Bongers, B. (2006). *Interactivation - Towards an E-cology of People, Our Technological Environment, and the Arts*. Lulu.com.

Box, H. (2010). *Set Lighting Technician's Handbook: Film Lighting Equipment, Practice, and Electrical Distribution* (4th edition). Fo-cal Press.

Branchi, W., & Pedio, R. (1979). Speaking Sounds: A Note on "Eclipse." *Perspectives of New Music*, *17*(2), 85–97.

Braun, C.-A., & Aziosmanoff, F. (2009). Intermedia Remediated & the Question of Designing Discourse. *Undisciplined! Proceedings: De-sign Research Society Conference 2008*. Retrieved from http://shura.shu.ac.uk/508/

Breder, H., & Busse, K.-P. (Eds.). (2005). *Intermedia: Enacting the Liminal*. Books On Demand.

Breder, H., & Rapaport, H. (2011). INTERMEDIA A Consciousness-based Process. *PAJ: A Journal of Performance and Art*, *33*(3), 11–23.

Bridgman, G. B. (1972). *The Human Machine: The Anatomical Structure & Mechanism of the Human Body* (1st ed.). Dover Publications.

Brook, D., & Ritchie, J. (1970). The Aesthetic Potential of the Sensory Modes. *Leonardo*, 415–424.

Brook, P. (2008). *Empty Space*. Penguin Books.

Bruner, J. S. (1974). *Toward a Theory of Instruction*. Belknap Press of Harvard University Press.

Burnham, L. F. (1986). "High Performance," Performance Art, and Me. *The Drama Review: TDR*, *30*(1), 15–51.

Cage, J. (1967). *A year from Monday*. Wesleyan University Press.

Caldwell, J. T. (1993). Televisuality as a Semiotic Machine: Emerging Paradigms in Low Theory. *Cinema Journal*, *32*(4), 24–48.

Campen, C. V. (2010). *The Hidden Sense: Synesthesia in Art and Science*. The MIT Press.

Carter, P. (2004). *Material Thinking: The Theory and Practice of Creative Research*. Melbourne University Press.

Carvalhais, M. (2010). *Towards a Model for Artificial Aesthetics: Contributions to the Study of Creative Practices in Procedural and Computational Systems* (PhD). Faculty of Fine Arts, University of Porto, Porto. Retrieved from http://www.carvalhais.org/txt/Carvalhais2010.pdf

Chase, G. (1967). Composers Have Their Say. In *Anuario* (Vol. 3, pp. 101–110). Retrieved from http://www.jstor.org/stable/779750

Choudhury, S., & Slaby, J. (Eds.). (2011). *Critical Neuroscience: A Handbook of the Social and Cultural Contexts of Neuroscience* (1st ed.). Wiley-Blackwell.

Chow, R. (2003). Kindness – a purpose of design. In *Proceedings of the 5th European Academy of Design Conference*. Barcelona, Spain: Interaction Design Foundation.

Christensen, R. C. (2009). The Art of Noise after Futurism. *Nordic Network of Avant-Garde Studies*. Retrieved from http://www.avantgardenet.eu/HAC/studentpapers/christensen_art_of_noise.pdf

Ciociola, C. (2011, 14 March). SoLu, correspondence between audio and visual spectrum. *Neural*. Critical digital culture and media arts. Retrieved 2 January 2014, from http://neural.it/2011/03/solu-correspondence-between-audio-and-visual-spectrum/

Clark, S. (2011). Revisiting interactive art systems. In *Proceedings of the 2011 international conference on Electronic Visualisation and the Arts* (pp. 205–205). Retrieved from *http://ewic.bcs.org/content/ConMediaFile/17880*

Coleridge, S. T. (1985). *The Collected Works of Samuel Taylor Coleridge, Volume 7: Biographia Literaria. (Two volume set)* (Vol. 7). Bollingen. Retrieved from http://books.google.com/books?hl=en&lr=&id=nkN03BMak4AC&oi=fnd&pg=PR13&dq=%22of+a+tacit+compact+among+the+learned+as%22+%22that+on+the+nature+and+genesis+of+the%22+%22its+causes+and%22+%22parts+of+language+the+product+of+philosophers,+not%22+&ots=yRelejXVmp&sig=Sze-W4RWtXsc_dvirYh_DhS_y44

Collopy, F. (2004). Three Centuries of Colour Scales. rhythmiclight.com. Retrieved from http://rhythmiclight.com/archives/ideas/colorscales.html

Cope, D., & Muscutt, K. (2007). Composing with Algorithms: An Interview with David Cope. *Computer Music Journal*, *31*(3), 10–22.

Cornock, S., & Edmond, E. (1973). The Creative Process Where the Artist is Amplified or Superseded by the Computer. *Leonardo*, *6*, 11–16.

Corrigan, R. W. (1966). The First Ten Years. *The Tulane Drama Review*, *10*(4), 17–19.

Cseres, J. (2009). In Between as a Permanent Status: Milan Adamčiak's Version of Intermedia. *Leonardo Music Journal*, *19*, 31–34.

Csikszentmihalyi, M., & Nakamura, J. (2002). The Concept of Flow. In C. R. Snyder & S. J. Lopez (Eds.), *Handbook of Positive Psychology* (pp. 89–105). Oxford University Press.

Daichendt, G. J. (2011). *Artist Scholar: Reflections on Writing and Research*. Intellect Ltd.

Dawkins, R. (2006). *The Selfish Gene: 30th Anniversary Edition*. Oxford University Press, USA.

Deleuze, G. (1987, May 17). *Qu'est-ce que l'acte de création?* Fondation Européenne pour les Métiers de l'Image et du Son. Retrieved from http://www.webdeleuze.com/php/texte.php?cle=134&groupe=Conf%E9rences&langue=1

Dias, B. (2012, May 17). Media, Intermedia, Theory and Practice. Retrieved from http://hyperinstrument.com/interviews/?p=440

Diderot, D. (1782, January 1). Encyclopédie ou dictionnaire raisonné des sciences, des arts et des métiers par une société de gens de lettres. In *Encyclopédie ou dictionnaire raisonné des sciences, des arts et des métiers par une société de gens de lettres*. Retrieved from https://play.google.com/store/books/details?id=mqRIrAD9ISEC&rdid=book-mqRIrAD9ISEC&rdot=1

Dobrian, C. (2008, August 21). Some Initial Thoughts on Algorithmic Composition. *Algorithmic Composition*. Retrieved from

http://algocomp.blogspot.pt/2008/08/some-initial-thoughts-on-algorithmic.html

Dorfles, G. (1980). Intermedia and Mixed Media as Sign of Crisis or a Re-birth of the Visual Arts. In *Theoretical Analysis of the Intermedia Art Form*. Salomon R. Guggenheim Museum.

Doruff, S. (2008). Who Done It? Ethico-aesthetics, the production of subjectivity and attribution. In *FLOSS+art* (pp. 118–127). openMute.

Dunning, A., & Woodrow, P. (2008). Body Degree Zero - Anatomy of an Interactive Performance. In *Transdisciplinary Digital Art - Sound, Vision and the New Screen* (pp. 46–59). Zurich, Switzerland and Victoria, BC, Canada: Springer.

Eco, U. (1962). *The Open Work*. Difel.

Edelson, M. B. (2005). Quality Power 1961-1978. In *Intermedia: Enacting the liminal*. Books On Demand.

Edmond, E., & Candy, L. (2010). Relating Theory, Practice and Evaluation in Practitioner Research. *Leonardo*, *43*(5), 470–476.

Edmonds, B. (2005). The revealed poverty of the gene-meme analogy – why memetics per se has failed to produce substantive results. *Journal of Memetics*, *9*(1).

Edmonds, B. (2009). The Survival of Memetics. In M. Ruse (Ed.), *Philosophy After Darwin: Classic and Contemporary Readings* (pp. 198–201). Princeton University Press.

Eisenkraft, A., Heltzel, C., Johnson, D., & Radcliffe, B. (2006). Artist as Chemist. *The Science Teacher*, 33–37.

Eldridge, A. (2013, January). Translation.

Elger, D., & Grosenick, U. (2004). *Dadaism*. Taschen.

Elstob, C. M. (1986). Indeterminism in System Science. In R. Trappl (Ed.), *Cybernetics and Systems '86* (pp. 79–86). Vienna, Austria: D. Reidel Publishing Company.

Enactivenetwork. (n.d.). Enactivenetwork. Enactivenetwork. Retrieved from http://enactivenetwork.org

Eskilson, S. (2003). Thomas Wilfred and Intermedia: Seeking a Framework for Lumia. *Leonardo*, *36*(1), 65–68.

Fairbairn, S. W. (1869). *Iron: its history, properties, & processes of manufacture*. Edinburgh: Adam and Charles Black.

Faulkner, W. (1996). *As I Lay Dying* (reprint.). Vintage Classic. Flusser,

V. (1999). *The Shape of Things*. Reaktion Books.

Flusser, V. (2010). *Writing* (1st ed.). São Paulo, Brazil: Annablume.

Fogassi, L., & Ferrari, P. F. (2007). Mirror neurons and the evolution of embodied language. *Current Directions in Psychological Science*, *16*(3), 136–141.

Fornäs, J. (2002). Passages Across Thresholds: Into the Borderlands of Mediation. *Convergence: The International Journal of Research into New Media Technologies*, *8*(4), 26.

Fornäs, J., Klein, K., Ladendorf, M., Sundén, J., & Sveningsson, M. (2002). Into Digital Borderlands. In *digital borderlands cultural studies of identity and interactivity on the internet* (p. 196). New York: Peter Lang.

Foster, H. (2003). Dada Mime. *October*, *105*(Summer, 2003), 166–176.

Foster, S. (1985). The Signifying Body: Reaction and Resistance in Post-modern Dance. *Theatre Journal*, *37*(1), 44–64.

Frank, P. (1974). The Avant Garde Festival: And Now, Shea Stadium. *Art in America*, *November/December*.

Frank, P. (1982). Soundings at SUNY. *Art Journal*, *42*(1), 58–62.

Frank, P. (2005). The Arts in Fusion: Intermedia Yesterday and Today. In H. Breder & K.-P. Busse (Eds.), *Intermedia: Enacting the liminal* (pp. 17–35). Books On Demand.

Freitas, N. de, & Lutnæs, E. (2007). Editorial: Making, materiality and knowledge in creative research. *Studies in Material Thinking*, *9*, 1–2.

Friedman, K. (2002, December 10). Intermedia. In *The Encyclopedia of New Media*. Sage Publications Inc.

Friedman, K. (2007). Intermedia, Multimedia, Media. Ken Friedman. Retrieved from http://www.intermediamfa.org/imd501/media/1232972617.pdf

Funk, M. (2012). SYNESTHESIA AND PHILOSOPHY – QUESTIONS OF OBJECTIVE AND SUBJECTIVE PERCEPTION. In *Synesthesia: Science and Art*. Almeria: Ediciones Fundación Int. Artecitta.

Gadamer, H.-G. (2004). *Truth and Method* (2nd ed.). Bloomsbury Academic.

Gallese, V., & Di Dio, C. (2012). Neuroesthetics: The Body in Aesthetic Experience. In (V. S. Ramachandran, Ed.) *The Encyclopedia of Human Behaviour*. Elsevier Academic Press.

Gardinali, P. R. (2012, Spring). Chemistry in Art - Course Syllabus. Florida International University. Retrieved from http://www2.fiu.edu/~gardinal/class_syllabi/IDS4920_SPRING 2012/Chemistry%20in%20art%20IDS-4920.pdf

Garfoot, A. (2005). *Dawn of the Neomodern: The Evolving Meme*. Lulu.com.

Garwood, D. (2007). The Future of an Idea 9 Evenings: Forty Years Later. *PAJ: A Journal of Performance and Art*, *29*(1), 36–48.

Gestel, N. V., Hunt, J., Quinn, D., Kream, R., Houssenloge, K., Holt, J., … Hunt, J. (2008). *The Unschooling Unmanual* (1 edition.). The Natural Child Project.

Giannetti, C. (n.d.). Aesthetics and communicative Context. *Media Art Net*. Retrieved 3 August 2013, from http://www.medienkunstnetz.de/themes/aesthetics_of_the_digital/aesthetics_and_communicative%20Context/1/

Gill, S. (2012). *Dancing Culture Religion* (1 edition.). Lexington Books.

Giuculescu, A. (1998). Order Versus Chaos or the Ghost of Indeterminacy. In H. Wautischer (Ed.), *The Proceedings of the Twentieth World Congress of Philosophy - Paideia: Philosophy Educating Humanity*. Boston, Massachusetts, U.S.A.

Glusberg, J. (1980). From Leonardo to Intermedia Revolution. In *Theoretical Analysis of the Intermedia Art Form*. Salomon R. Guggenheim Museum.

Gourlay, S., & Nurse, A. (2005). FLAWS IN THE "ENGINE" OF KNOWL-EDGE CREATION - A Critique of Nonaka's Theory. In A. F. Buono (Ed.), *Challenges and Issues in Knowledge Management* (pp. 293–251). Information Age Publishing.

Grady, E. (2011, 18 March). SynDyn. *SparkFun*. Electronics. Retrieved from https://www.sparkfun.com/news/571

Greenfield, A. (2006). *Everyware: The Dawning Age of Ubiquitous Computing* (1st edition.). New Riders Publishing.

Guattari, F. (1995). *Chaosmosis: An Ethico-Aesthetic Paradigm*. Indiana University Press.

Guedes, C. (2005). *Mapping Movement to Musical Rhythm: A Study in Interactive Dance* (PhD). New York University, New York.

Hall, J. (2010). An Autopoietic Aesthetic for Interactive Robotic Installation. Jennifer Hall. Retrieved from http://www.jenhall.org/autopoetic.html

Halsall, F. (2008). *Systems of Art: Art, History and Systems Theory* (1st ed.). Verlag Peter Lang.

Hamilton, W. D. (1977). The Play by Nature. *Science*, *196*(4291), 757–759.

Hannan, M. (2006). Intermedia collaboration for The Flood. *Contemporary Music Review*, *25*(4), 327–339. doi:10.1080/07494460600760999

Hardt, H. (2005). The Interdisciplinary and Intertextual World of Hans Breder. In H. Breder & K.-P. Busse (Eds.), *Intermedia: Enacting the liminal* (pp. 234–239). Books On Demand.

Harrison, C., & Wood, P. (Eds.). (2003). *Art in theory, 1900-2000* (2nd ed.). Wiley-Blackwell.

Hawkins, H. (2010). The argument of the eye: Cultural geographies of installation art. *Cultural Geographies*, *17*(3), 321–340. doi:10.1177/1474474010368605

Hawkins, H. (2012). Geography and art. An expanding field: Site, the body and practice. *Progress in Human Geography*, *37*(1), 52–71. doi:10.1177/0309132512442865

Hazelrigg, L. (1988). *SOCIAL SCIENCE AND THE CHALLENGE OF RELATIVISM Claims of Knowledge: On the Labour of Making*

Found Worlds. Tallahassee, Fl, U.S.A.: University Press of Florida.

Heidegger, M. (1977). *The Question Concerning Technology and Other Essays*. (W. Lovitt, Trans.). Garland Publishing.

Heidegger, M. (1995). *Language of Tradition and Language of Technique* (1st ed.). Vega.

Helm, F. (2005). Vilém Flusser's Theory of Communication: The Voice of Jacob. In *Passions in Economy, Politics, And the Media: In Discussion With Christian.* (pp. 447–462). Wien: LIT Verlag.

Hertz, P. (1999). Synesthetic Art: An Imaginary Number? *Leonardo*, *32*(5), 399–404.

Heylighen, F. (2013). Autopoiesis. *Web Dictionary of Cybernetics and Systems*. Retrieved from http://pespmc1.vub.ac.be/ASC/AUTOPOIESIS.html

Higgins, D. (1966a). Intending. *The Something Else NEWSLETTER*, *1*(2). Higgins, D.

(1966b). Intermedia. *The Something Else NEWSLETTER*, *1*(1).

Higgins, D. (Ed.). (1966c). Manifestos - Great Bear Pamphlet by Something Else Press. Something Else Press. Retrieved from http://www.ubu.com/historical/manifestoes/index.html

Higgins, D. (1968). Boredom and Danger. *The Something Else NEWSLETTER*, *1*(9). Retrieved from http://primaryinformation.org/SEP/Something-Else-Press_News letter_V1N9.pdf

Higgins, D. (1976). The Origin of Happening. *American Speech*, 268–271.

Higgins, D. (1979). The New Humanism. *PAJ: A Journal of Performance and Art*, *4*(1/2), 23–32.

Higgins, D. (1995). Intermedia Chart. Estate of Dick Higgins. Higgins, D.

(1998). *Horizons*. Roof Books.

Higgins, D., & Higgins, H. (2001). Intermedia. *Leonardo*, *34*(1), 49–54.

Higgins, D., & Zurbrugg, N. (1999). Looking Back. *PAJ: A Journal of Performance and Art*, *21*(2), 19–32.

Higgins, H. (2002). Intermedial Perception or Fluxing Across the Sensory. *Convergence: The International Journal of Research into New Media Technologies*, *8*(4), 59–76. doi:10.1177/135485650200800407

Higgins, K. M. (2012). *The Music between Us: Is Music a Universal Language?* University of Chicago Press.

Hjelm, S. I. (2004). Artefacts as Research. In *Proceedings of ACM CHI 2004 Conference on Human Factors in Computing Systems*. ACM Press. Retrieved from http://www.smart.tii.se/smart/publications/pubs/ArtefactsAsResearch.pdf

Hoffmann, R. (1993). *Herbert F. Johnson Museum of Art annual report: 1992–1993* (pp. 9–11). The Museum, Cornell University.

Hoffmann, R. (2012). *Roald Hoffmann on the Philosophy, Art, and Science of Chemistry*. (J. Kovac & M. Weisberg, Eds.). Oxford University Press, USA.

Horton, R. (2000). Genetically modified food: consternation, confusion, and crack-up. *The Medical Journal of Australia*, *4*(172), 148–149.

Howlett, P., & Morgan, M. S. (Eds.). (2010). Tacit Knowledge - Making it Explicit. London School of Economics and Political Science. Retrieved from

http://www.lse.ac.uk/economicHistory/Research/facts/AboutThe Project.aspx

Jahnke, M. (2012). Revisiting Design as a Hermeneutic Practice: An Investigation of Paul Ricoeur's Critical Hermeneutics. *Design Issues*, *28*(2), 30–40.

Jewanski, J. (n.d.). Lumia. *See This Sound*. Retrieved from http://www.see-this-sound.at/works/522

Jobs, S. (2011, 2 March). *Apple's iPad2 Launch*. Retrieved from http://www.youtube.com/watch?v=XdSQbVFobu4

Johnson, M. (2008). *The Meaning of the Body: Aesthetics of Human Understanding*. University of Chicago Press.

Kahn, D. (1999). *Noise, Water, Meat: A History of Sound in the Arts*. New York: MIT.

Kaplan, H. M. (2008, June). *Realism, Idealism, and the Commitments of Common Sense* (PhD). Northwestern University, Evanston, Illinois.

Kaplan, J. A., Hendricks, B., Hendricks, G., Higgins, H., & Knowles, A. (2000). Flux generations. *Art Journal*, 7–17.

Kaprow, A. (1966). Manifestos - A Great Bear Pamphlet. Something Else Press.

Kase, C. (2009). *A Cinema of Anxiety: American Experimental Film in the Realm of Art (1965–75)*. UNIVERSITY OF SOUTHERN CALIFORNIA. FORNIA. Retrieved from http://digitallibrary.usc.edu/assetserver/controller/item/etd-Kase-3268.pdf

Kay, A. (1982, July 20). *Creative Think*. Presented at the Creative Think. Retrieved from http://folklore.org/StoryView.py?story=Creative_Think.txt

Eysenck, M., & Keane, M. T. (2010). *Cognitive Psychology: A Student's Handbook, 6th Edition* (6 edition.). Psychology Press.

Kirby, M. (1965). The New Theatre. *The Tulane Drama Review*, 23–43.

Kirby, M. (1969). *The Art of Time: Essays on the Avant-Garde*. New York: E.P. Dutton & Co.

Knapton, J. (1999). *Single Pour Industrial Floor Slabs: Specification, Design, Construction and Behaviour*. ICE Publishing.

Kniffin, K. M., & Hanks, A. S. (2013, October 17). Boundary Spanning in Academia: Antecedents and Near-Term Consequences of Academic Entrepreneurialism. Cornell Higher Education Research Institute (CHERI). Retrieved from http://ssrn.com/abstract=2341780

Kodish, B. (2003). *Dare to Inquire: Sanity and Survival for the 21st Century and Beyond*. Extensional Pub.

Koskinen, I., Zimmerman, Z., Binder, T., Redstrom, J., & Wensveen, S. (2011). *Design Research through Practice: From the Lab, Field, and Showroom*. Morgan Kaufmann.

Kosslyn, S. M. (1996). *Image and Brain: The Resolution of the Imagery Debate*. A Bradford Book.

Kostelanetz, R. (1999). Dick Higgins (1938-1998). *PAJ: A Journal of Performance and Art*, *21*(2), 11–17.

Kotler, P. (1986). Prosumers: A New Type of Consumer. *Futurist*, *20*(5), 24.

Krisitansen, D. M. (1968). What Is Dada? *Educational Theatre Journal*, *20*(3), 457–462.

Kultermann, U. (1980). Towards a Definition of Intermedia. In *Theoretical Analysis of the Intermedia Art Form*. Salomon R. Guggenheim Museum.

Landhäußer, A., & Keller, J. (2012). Flow and Its Affective, Cognitive and Performance-Related Consequences. In S. Engeser (Ed.), *Advances in Flow Research* (p. 200). Springer.

Langrish, J. Z. (1999). Different Types of Memes: Recipemes, Selectemes, and Explanemes. *Journal of Memetics*, *3*(2), 109–122.

Langrish, J. Z. (2004). Darwinian Design: The Memetic Evolution of Design Ideas. *Design Issues*, *20*(4).

Lawson, D. M. (2004). *Posterity: Letters of Great Americans to Their Children* (1st Edition.). Doubleday.

Leal, M. (2009). *Blind imagination: Mechanisms of indeterminacy in contemporary artistic practice*. Faculty of Fine Arts, University of Porto.

Leroi-Gourhan, A. (1993). *Gesture and Speech*. The MIT Press.

Levere, T. H. (2001). *Transforming matter: a history of chemistry from alchemy to the buckyball*. The Johns Hopkins University Press.

Lochhead, J. I. (1994). Performance Practice in the Indeterminate Works of John Cage. *Performance Practice Review*, *7*(2), 11.

Lorber, R. (1974). Epistemological TV. *Art Journal*, *34*(2), 132–134.

Luhmann, N. (1986). The autopoiesis of social systems. In F. Geyer & J. V. der Zouwen (Eds.), *Sociocybernetic Paradoxes: Observation, Control and Evolution of Self-Steering Systems (p. 248). SAGE Publications Ltd.*

trol and Evolution of Self-Steering Systems (p. 248). SAGE Publications Ltd.

Macedo, A. R. (2002). *Dem#0: moderate spatial deterritorialisation* (Master's Thesis). Portuguese Catholic University, Porto.

Macedo, A. R. (2005, January). AutomatD. Virose.pt. Retrieved from http://www.virose.pt/vector/b_12/rangel.html

Macedo, A. R. (2010). From the Art of Representation to the Art of Presentation - a change accelerated by communication technologies and real-time information processing. In *Proceedings CI-ANTEC*. São Paulo, Brazil: CIANTEC.

Macedo, A. R. (2011, May). André Rangel Macedo For Flusser From 3kta. *Flusser Studies*, (11). Retrieved from http://www.flusserstudies.net/pag/archive11.htm

Macedo, A. R. (2013, 2 January). Two New Experiments Using 'EEG'. Retrieved from private communication

Machover, T. (1992). *Hyperinstruments - A Progress Report 1987 - 1991*. MIT Media Laboratory. Retrieved from http://opera.media.mit.edu/hyper_rprt.pdf

Maresca, P. (2003). Introduction to the fundamentals of algorithms. In S. K. Chang (Ed.), *Data Structures and Algorithms*. Singapore: World Scientific Publishing Co.

Marranca, B. (2006). Performance, a personal history. *PAJ: A Journal of Performance and Art*, *28*(1), 3–19.

Martins, L. G., & Barbosa, Á. (2013). NIME Education at the School of Arts of the Portuguese Catholic University / CITAR. In *2013 Learning and Teaching in Computing and Engineering* (pp. 237–238). Ma-

cau: The Institute of Electrical and Electronics Engineers, Inc. doi:http://doi.ieeecomputersociety.org/10.1109/LaTiCE.2013.50

Maturana, H. (2013, January 19). *II Congreso del Futuro*. Retrieved from http://www.youtube.com/watch?v=hlhMNve1qAY

Maturana, H. R., & Varela, F. J. (1980). *Autopoiesis and Cognition: The Realisation of the Living*. D. Reidel Publishing Company.

McCombe, C. (2006). Videomusicvideo—composing across media. *Contemporary Music Review*, *25*(4), 299–310. doi:10.1080/07494460600760973

McCormack, D. P. (2004). Drawing out the lines of the event. *Cultural Geographies*, *11*(2), 211–220. doi:10.1191/14744744004eu303xx

McLuhan, M. (1994). *Understanding Media: The Extensions of Man* (1st MIT Press ed.). MIT Press.

McNeill, D. (2005). *Gesture and Thought*. University of Chicago Press.

McNeill, D. (2006). Gesture and Thought. University of Chicago. Retrieved from http://mcneilllab.uchicago.edu/pdfs/dmcn_vietri_sul_mare.pdf

MCTES. (2009, 14 September). Decree-Law No. 230/2009. Diário da República. Retrieved from http://www.dges.mctes.pt/NR/rdonlyres/90DBE647-5CB6-4846-B88F-101180D9E425/4627/DL_230_2009.pdf

Meier, J. (2012). Genuine thought is inter(medial). In B. Herzogenrath (Ed.), *Travels in Intermediality: ReBlurring the Boundaries* (p. 286). Dartmouth.

Melo, R., & Carvalhais, M. (2013). The Design of Horacle: Inducing Serendipity on the Web. In M. Verdichio & M. Carvalhais (Eds.), *xCoAx*

2013: Proceedings of the first conference on Computation, Communication, Aesthetics and X (pp. 183–192). Bergamo: xCoAx. Retrieved from http://2013.xcoax.org/xcoax2013.pdf

Merleau-Pony, M. (2012). *Phenomenology of Perception*. (D. Landes, Trans.). Routledge.

Michael, P. (2009). *The Tacit Dimension. With a new foreword by Amartya Sen*. The University of Chicago Press.

Miller, D. (2003). The Shapes of Indeterminacy: John Cage's Variations I and Variations II. *Frankfurter Zeitschrift Für Musikwissenschaft*, *6*, 18.

Miller, D. P. (2009). Indeterminacy and Performance Practice in Cage's "Variations." *American Music*, *27*(1), 60–86.

Miller, L. E. (2001). Cage, Cunningham, and collaborators: The Odyssey of variations V. *Musical Quarterly*, *85*(3), 545–567.

Miller, L. J. (2012). *The Oxford Handbook of Psychology and Spirituality*. Oxford University Press, USA.

Modogno, V. (2011, 30 March). Syndyn, artistic sport game. *comandC*. blog. Retrieved from http://comandc.blogspot.pt/2011/03/syndyn-artistic-sport-game. html

Mohammadi, G., & Vinciarelli, A. (2010). Towards a technology of nonverbal communication: vocal behaviour in social and affective phenomena. In D. Gökçay & G. Yildirim (Eds.), *Affective Computing and Interaction: Psychological, Cognitive and Neuroscientific Perspectives* (p. 458). IGI Global.

Molenda, M. (2003). Cone of experience. *Educational Technology: An Encyclopaedia*. Retrieved from

http://www.coachesbc.ca/pdfs/lfs/cone%20of%20experiencetext. pdf

Molesworth, H. (2003). From Dada to Neo-Dada and Back Again. *October*, *105*(Summer, 2003), 171–181.

Monico, F. (n.d.). 9 - Autopoietic Principle. *The Hybrid Constitution*. Retrieved from http://hybridconstitution.blogspot.pt/2011/11/9-auotopoietic-pri nciple.html

Monochrome, C. (2005). Experience the Experience. Monochrome. Retrieved from http://www.monochrom.at/experiences/manifesto.htm

Montes, L. D. (2013). Review of Roald Hoffmann on the Philosophy, Art, and Science of Chemistry. *Journal of Chemical Education*, *90*(4), 405–406. doi:10.1021/ed4001602

Moody, A. E. (2000). JINS 331: The Chemistry of Art. Truman State University. Retrieved from http://chem.truman.edu/pdf/ChemArt.pdf

Moravanszky, Á. (1996). "Truth to Material" vs "The Principle of Cladding": The Language of Materials in Architecture. *AA Files: Annals of the Architectural Association School of Architecture*, *31*, 39–46.

Moyal-Sharrock, D. (2013). Wittgenstein Today. In *International Conference on Wittgenstein and Contemporary Philosophy*. Beijing Normal University: Chinese Society for Contemporary Foreign Philosophy.

Murdoch, I. (2001). *The Sovereignty of Good* (2nd ed.). Routledge.

Naisbitt, N., & Naisbitt, J. (2000, June 19). Will Low Tech Replace High Tech? *Time - New York*, *155*(25), 108–110.

Nelson, W. C. (1982). INDETERMINISM VS. DETERMINISM. In *An Ad-Advanced Treatise In SUBSPACE and QUANTUM ASPECTS of BI-OLOGY*. Academy press. N.M.

Niebisch, A. (2013). Feedback: Media Parasites and the Circuits of Communication (Dada and Burroughs). *Semiotic Review*, (1), 1–7.

Nierhaus, G. (2010). *Algorithmic Composition: Paradigms of Automated Music Generation* (1st ed.). Springer.

Noë, A. (2004). *Action in Perception*. MIT Press.

Noë, A., & Thompson, E. (2002). Introduction. In A. Noë & E. Thompson (Eds.), *Vision and Mind: Selected Readings in the Philosophy of Perception* (p. 637). MIT Press.

Nonaka, I. (1994). 1994_Nonaka94.pdf. *Organisation Science*, *5*(1), 14–37.

Oosterling, H. (2003). Sens (a) ble Intermediality and Interest: Towards an Ontology of the In-between. *Intermédialités: Histoire et Théo-rie Des Arts, Des Lettres et Des Techniques*, (1). Retrieved from http://www.erudit.org/revue/im/2003/v/n1/1005443ar.html?vue=resume

Ox, J. (1999a). Introduction: Colour Me Synesthesia. *Leonardo*, *32*(1), 7–8.

Ox, J. (2001). Intersenses/Intermedia: A Theoretical Perspective. *Leonardo*, *34*(1), 47–48.

Packer, R., & Jordan, K. (2001). *Multimedia: from Wagner to virtual reality* (1st ed.). New York: Norton.

Parker-Starbuck, J. (2011). The Spectatorial Body in Multimedia Performance. *PAJ: A Journal of Performance and Art*, *33*(3), 60–71.

Pasquinelli, E., & Stewart, J. (2007). Enactive Knowledge. Elena Pasquinelli. Retrieved from https://sites.google.com/site/elenapasquinelli/pasquinelli_2007_lexicon_n.pdf

Paul, C. (2002). Renderings of digital art. *Leonardo*, *35*(5), 471–484.

Perrusi, A. (2004, October). Technique in the Humanisation of Homo Sapiens Sapiens: Comments on Leroi-Gourhan's View of Technique. *Política e Trabalho Revista de Ciências Sociais*, (21), 61–67.

Philpott, R. (2007). Engineering Opportunities for Originality and Invention: The importance of playful making as developmental method in practice-led design research. *Studies in Material Thinking*, *9*.

Popper, F. (2007). *From technological to virtual art*. Cambridge, Mass.: MIT Press.

Porto, M. (2007). Grasses. University of Coimbra. Retrieved from http://www.uc.pt/herbario_digital/Flora_PT/Familias/gramineas/

Povall, R. M. (1993). "The Last Garden": Explorations in Interactive Performance Methods. *Leonardo Music Journal*, 25–28.

Poyau, M. (2011, 28 March). Can Sports and Art Finally Come Together In This Interactive Installation? *The Creators Project*. Global Celebration of Art and Technology. Retrieved from http://thecreatorsproject.vice.com/blog/can-sports-and-art-finally-come-together-in-this-interactive-installation

Preimesberger, R. (2011). *Paragons and Paragone: Van Eyck, Raphael, Michelangelo, Caravaggio, and Bernini*. Getty Research Institute.

Reed, H. L. (1996). *Brains for Machines: Machines for Brains*. Nova Science Publishers, Incorporated.

Refsum, G. (2002). Contribution to an understanding of the knowledge base in the field of visual arts. *Working Papers in Art and Design*, *2*. Retrieved from http://sitem.herts.ac.uk/artdes_research/ papers/wpades/ vol2/refsumfull.html

Rheinberg, F. (2008). Intrinsic motivation and flow-experience. In J. Heckhausen & H. Heckhausen (Eds.), *Motivation and action* (pp. 323–348). Cambridge University Press.

Rheinberger, H.-J. (1998). Experimental Systems, Graphematic Spaces. In T. Lenoir (Ed.), *Inscribing Science: Scientific Texts and the Materiality of Communication* (pp. 285–303). Stanford University Press.

Robinson, J. (2009, Winter). From Abstraction to Model: George Brecht's Events and the Conceptual Turn in Art of the 1960s*. *October*, (127), 77–108.

Rogers, C. R. (1961). *On becoming a person: a therapist's view of psychotherapy*. London: Constable.

Rogers, H. (2011). The Unification of the Senses: Intermediality in Video Art-Music. *Journal of the Royal Musical Association*, *136*(2), 399–428. doi:10.1080/02690403.2011.618727

Rojcewicz, R. (2006). *The Gods and Technology: A Reading of Heidegger*. State University of New York Press.

Roochnik, D. (2013). *Retrieving Aristotle in an Age of Crisis*. State University of New York Press.

Ross, K., & Nightingale, V. (2003). *Media and Audiences (Issues in Cultural and Media Studies)*. Open University Press.

Ross, S. (1994). *Art and Its Significance: An Anthology of Aesthetic Theory* (Third Edition). State University of New York Press.

Russolo, L. (1967). The Art of Noise. Something Else Press.

Ryan, J. (Ed.). (2005). *How Does Psychotherapy Work?* Karnac Books.

Sabatini, A. J. (2005). Robert Ashley: Defining American Opera. *PAJ: A Journal of Performance and Art*, *27*(2), 45–60.

Scarinzi, A. (2013). Aesthetics and the Embodied Mind: Beyond Art Theory and the Cartesian Mind-Body Dichotomy. Springer. Retrieved from https://sites.google.com/site/aestheticsandtheembodiedmind/ho me

Schechner, R. (1967b). The Journal of Environmental Theatre. *The Tulane Drama Review*, *11*(3), 19–22.

Schechner, R. (1968a). 6 Axioms for Environmental Theatre. *The Drama Review: TDR*, 41–64.

Schechner, R. (1968b). Group V: Improving Design for the Technical Function: Scenography, Structure and Function. *Educational Theatre Journal*, *20*(2), 311–316.

Schinkel, W. (2010). The Autopoiesis of the Artworld after the End of Art. *Cultural Sociology*, *4*(2), 267–290. doi:10.1177/1749975510368476

Schmitt, A. (2000). Algorithm. Gratin.org. Retrieved from http://www.gratin.org/as/txts/algorithme.html

Schneider, R. (2000). Nomadmedia: On Critical Art Ensemble. *The Drama Review: TDR*, *44*(4), 120–131.

Schön, D. A. (1992). Design as reflective conversation with the materials of a design situation. *Knowledge-Based Systems*, *5*(1), 3–13.

Schüler, J., & Engeser, S. (2009). Incentives and flow experience in learning settings and the moderating role of individual differences. In M. Wosnitza, S. A. Karabenick, A. Efklides, & P. Nenniger (Eds.), *Contemporary Motivation Research: From Global to Local Perspectives* (1st ed., p. 378). Hogrefe Publishing.

Seidl, D. (2004). Luhmann's theory of autopoietic social systems. *Munich Business Research Paper*, (2004-2). Retrieved from http://www.zfog.bwl.uni-muenchen.de/files/mitarbeiter/paper2004_2.pdf

Selden, M. S. (1962). Early Roots of Russian Opera. *Journal of the American Musicological Society*, 206–211.

Semin, G. R. (1998). Cognition, language, and communication. *Social and Cognitive Approaches to Interpersonal Communication*, 229–257.

Sgobbi, L. (2011, May). 3kta +André Rangel and Anne-Kathrin Siegel. *DAAF*. Design Architecture Art Fashion. Retrieved from http://www.daafportal.com/index.php?option=com_k2&view=item&id=356:3kta-+-andrè-rangel-e-anne-kathrin-siegel&lang=en

Shankman, S., & Durrant, S. (n.d.). *The Siren and the Sage: Knowledge and Wisdom in Ancient Greece and China* (1st edition.). Continuum.

Shatnoff, J. (1967). Expo 67: A multiple vision. *Film Quarterly*, *21*(1), 2–13.

Shifman, L. (2013). *Memes in Digital Culture*. The MIT Press. Spark,

N. T. (2006). *A History of Murphy's Law*. Periscope Film.

Spector, T. I., & Spalding, D. (2003). Between Chemistry and Art. *HYLE-International Journal for Philosophy of Chemistry*, *9*(2), 233–243.

Spielmann, Y. (2001). Intermedia in Electronic Images. *Leonardo*, *34*(1), 55–61.

Spielmann, Y. (2005). History and Theory of Intermedia in Visual Culture (Manuscript of the Paper Presentation). In H. Breder & K.-P. Busse (Eds.), *Intermedia: Enacting the liminal* (pp. 131–138). Books On Demand.

Spielmann, Y. (2006). Video: From Technology to Medium. *Art Journal*, *65*(3), 54–69.

Spulle, U., & Pusinskis, V. (2007). Research of Strength of Europallets. In S. Kurjatko, J. Kúdela, & Lagaña Rastislav (Eds.), *Wood Structure and Properties '06*. Sielnica, Slovakia: Arbora Publishers.

Stice, J. (2009). A REFUTATION OF THE PERCENTAGES OFTEN ASSOCIATED WITH EDGAR DALE'S "CONE OF LEARNING." In *ANNUAL CONFERENCE PROCEEDINGS—AMERICAN SOCIETY FOR ENGINEERING EDUCATION; AC 2009-1546*. ASEE—American Society for Engineering Education.

Stolt, M. H., & Rebenhorst, M. C. (2011). Subaqueous Soils. In P. M. Huang, Y. Li, & M. E. Summer (Eds.), *Handbook of Soil Sciences: Properties and Processes, Second Edition* (2nd edition, p. 1442). CRC Press.

Sullivan, G. (2006). Research Acts in Art and Practice. *Studies in Art and Education*, *48*(1), 19–35.

Sullivan, G. (2009). *Art Practice as Research: Inquiry in Visual Arts* (2nd ed.). Sage Publications Inc.

Sumich, J. S. (2007). *Conceptual Fusion Coleridge, Higgins, and the Intermedium*. University of Auckland. Retrieved from http://www.intermedia.ac.nz/pdfs/ConceptualFusionISBN.pdf

Sun, C. (2013, March 19). Experimental music. Oxford University Press. Retrieved from http://www.oxfordmusiconline.com/subscriber/article/grove/music/A2224296

Swank, J. M. (2011). *History of the Manufacture of Iron in All Ages: And Particularly in the United States from Colonial Time to 1891*. Cambridge University Press.

Teixeira, J. de F. (1998). *Minds and machines: an introduction to cognitive science*. Porto Alegre: Artes Médicas.

Tezuka, M. (2011). Experimentation and Tradition: The Avant-Garde Play Pierrot Lunaire by Jikken Kōbō and Takechi Tetsuji. *Art Journal*, *70*(3), 65–85.

Tin, M. B. (2012). Manifesto: Making and the sense it makes. *Studies in Material Thinking*, *9*, 1–5.

Tinkler, P., & Jackson, C. (2004). *The Doctoral Examination Process: A Handbook for Students, Examiners and Supervisors*. Open University Press.

Tisdall, C., & Bozzolla, A. (1978a). Literature and Theatre. In *Futurism* (Vol. 20). Oxford University Press.

Tisdall, C., & Bozzolla, A. (1978b). The Means of Futurism. In *Futurism* (Vol. 20). Oxford University Press.

Tresilian, N. (2004). Reflections on the Art-Historical "Big Picture." In P. A. Harris & M. Crawford (Eds.), *Time and Uncertainty* (p. 261). Brill Academic Pub.

Tresilian, N. (2008). The Swarming of memes. *Technoetic Arts: A Journal of Speculative Research*, *6*(2), 115–126. doi:10.1386/tear6.2.115/1

Truckenbrod, J. (1992). Integrated Creativity: Transcending the Boundaries of Visual Art, Music and Literature. *Leonardo Music Journal*, 89–95.

Tyler, T. (2011). *Memetics: Memes and the Science of Cultural Evolution.* CreateSpace Independent Publishing Platform.

Ulmer, G. L. (1977). Borges and Conceptual Art. *Boundary 2*, *5*(3), 845–862.

Varela, F. J. (1991). *The Embodied Mind: Cognitive Science and Human Experience* (First MIT Press paperback edition, 1993.). MIT Press.

Vasconcelos, L. A. L. de. (2009, November). *An Investigation into Design Methodologies*. Federal University of Pernambuco - UFPE, Pernambuco, Brazil.

Vaughan, L. (2007). Material Thinking as Place Making. *Studies in Material Thinking*, *1*(1), 1–2.

Verganti, R. (2009). *Design-driven innovation: changing the rules of competition by radically innovating what things mean.* Harvard Business Press.

Virilio, P. (2005). *The Accident of Art*. Semiotext(e). Virilio, P.

(2006). *Art and Fear*. Continuum.

Von Békésy, G. (1960). *Experiments in Hearing*. McGraw-Hill Inc., US.

Vranas, P. (2005). The indeterminacy paradox: Character evaluations and human psychology. *Nous*, *39*(1), 1–42.

Walley, J. (2011). Identity Crisis: Experimental Film and Artistic Expansion∗. *October*, 23–50.

Wegner, P. (1996, October 14). *The Paradigm Shift from Algorithms to Interaction*. Brown University. Retrieved from http://cs.brown.edu/people/pw/papers/ficacm.ps

Weibel, P. (2001). Sciences of the interface: proceedings of the International Symposium Sciences of the Interface. In *proceedings of the International Symposium Sciences of the Interface*. Genista.

Weibel, P. (2006). Postmedia Condition. Conde Duque Cultural Centre, Madrid. Retrieved from http://www.medialabmadrid.org/medialab/medialab.php?l=0&a=a&i=329

Weissensteiner, E., & Freksa, C. (2012). Wolkenkuckucksheim: Art as Metaphor of the Mind. *Leonardo*, *45*(5), 414–422.

Wenders, W. (2013, 17 July). Wisdom Wednesday: Wim Wenders' 50 (that's right, 50) Golden Rules of Moviemaking. *Movie Maker Magazine*. Retrieved from http://www.moviemaker.com/articles-directing/wim-wenders-50-golden-rules-of-moviemaking/

Wendt, L. (1985). Sound Poetry: I. History of Electro-Acoustic Approaches II. Connections to Advanced Electronic Technologies. *Leonardo*, 11–23.

Wilson, S. (2003). *Information Arts: Intersections of Art, Science, and Technology*. MIT Press.

Wright, R. (2010). *The Evolution of God: The origins of our beliefs*. Abacus.

Wurth, K. B. (2006). Multimediality, Intermediality, and Medially Complex Digital Poetry. *RiLUnE*, (5), 1–18.

Youngblood, G. (1970). *Expanded Cinema* (First edition.). E P Dutton. Zarrilli, P.

(2012). *THE PSYCHOPHYSICAL ACTOR AT WORK*. Routledge.

Zatti, M. (2003). Indeterminacy a Necessary Condition for Free Will. *Humanitas*, *XVI*(2), 107–118.

Ziarek, K. (2007). Enactive Art: Thinking and Multiplicity. *Bryn Mawr Review of Comparative Literature*, *6*(1). Retrieved from http://www.brynmawr.edu/bmrcl/Winter2007/Ziarek.htm

Zimmerman, J., & Forlizzi, J. (2008). The role of design artefacts in design theory construction. *Artifact*, *2*(1), 41–45.

Zuras, M. (2010, June 2). Tech Art History, Part 2. *switched*. Retrieved from http://www.switched.com/2010/06/03/tech-art-history-part-2/